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LIVESTOCK-FISHERY INTERACTION STUDIES
TABOR CREEK, NEVADA

Progress Report 4 to the USDI Bureau of Land Management
Nevada State Office, Reno, Nevada
and Elko District Office, Elko, Nevada

May 1982 to April 1983

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EXECUTIVE SUMMARY

The Tabor Creek, Nevada, portion of the Livestock-Fishery Interaction Studies is an intensive effort to monitor and evaluate the effects of continuous and rest-rotation grazing and complete rest on aquatic and streamside habitat and fish populations of a representative Great Basin stream.

Streamside and aquatic habitat conditions rested within an exclosure for several years were consistently superior to adjacent seasonally heavily-grazed areas. These differences were presumed due to the rest from grazing, though pre-exclosure data were not available to quantitatively determine pre-rest conditions. Trout populations within the rested stream section were not necessarily larger than outside despite apparently better habitat. The reasons for this are unclear, but stocking and angling are suggested as possible influential factors; however, sculpin populations suggest the influence of some unidentified but overriding superior habitat parameter in one of the grazed areas.

A new exclosure around one of the grazed sites was completed in 1982, and rest-rotation grazing was initiated inside the previously rested area. The new exclosure was not completed in time to prevent grazing, so no immediate effects of rest could be evaluated. Grazing inside the previously rested area, however, appeared to have immediate impacts on streambank vegetation and structure.

Additional and more conclusive evaluation of these various grazing treatments will become available as data for time trend analysis accumulates.

PREFACE

This report is the fourth in a series of progress reports that report the results of the Livestock-Fishery Interaction Studies on Tabor Creek, Nevada and, although it is intended to supplement Progress Reports 1 and 2 (Platts and others 1980; Platts and Nelson 1981), it is also designed to be an independent document. The reader may, however, wish to refer to the previous progress reports to gain a more thorough understanding of the scope of this study.

ACKNOWLEDGEMENTS

This progress report contains information gleaned from a variety of sources. Most of the specific information regarding the history and condition of the Tabor Creek area was distilled from materials provided by Val Crispin, USDI, Bureau of Land Management (BLM), Elko, Nevada, which includes the Nevada joint Department of Conservation and Natural Resources and U. S. Department of Agriculture publication (1963) describing the Mary's River Sub-basin. In an effort to limit distraction caused by abundant and unwieldy referencing, this publication and official material on file with the BLM are cited only when documentation is deemed necessary by the authors. Further appreciation is extended to Osborne Casey, State Fisheries Biologist, USDI, Bureau of Land Management, Nevada State Office, Reno, Nevada, and Roy Masinton, Fisheries Biologist, BLM, Elko District Office, Elko, Nevada, for their efforts in coordinating this study.

INTRODUCTION

There are 1.9 billion acres of land in the 48 conterminous United States, of which some 1.2 billion or 63 percent are rangelands, and, as of 1970, 69 percent of this acreage was grazed by domestic livestock. Although representing relatively little acreage themselves, streams of various sizes traverse this vast area. Unfortunately, they have often been ignored in rangeland planning.

The various classes of livestock utilize the range in different ways, necessitating different management practices to increase the compatibility of each class with riparian and aquatic habitat. Cattle, for example, will congregate on lesser slopes and bottomlands, while sheep, which are less dependent on water, usually favor steeper slopes and upland areas. Since sheep are also usually herded whereas cattle are not, management techniques to keep watersheds from being significantly altered differ between these two classes of livestock. The commonly used cattle management techniques are suspected to be less congenial than those used with sheep and are therefore the focus of this study.

Since the riparian zone, which forms the interface between the aquatic and the drier terrestrial range ecosystems, is disproportionately important to both systems, application of effective management to this ecosystem is critical. Because of soil moisture, soil fertility, and related factors, the riparian ecosystem is more productive than the drier upland range, and its vegetation is more palatable. Coupled with this are other riparian features, such as gentler terrain, increased shade, and drinking water, which add to the attractiveness of this zone to cattle and can lead to preferential use.

The riparian zone also provides vitally important fishery habitat components, largely a result of streamside vegetation. Overhanging vegetation and undercut streambanks are an important source of protective cover, food, and shade. Shading prevents water temperatures from rising or fluctuating drastically, which can lead to shifts in species composition from salmonids to more tolerant species of non-game fish (Platts in press). In addition, detritus formed from terrestrial plants is a principal source of food for aquatic invertebrates and ultimately fish (Minshall 1967). Streamside vegetation also serves as a barrier to terrestrial pollutants and controls water velocity and streambank erosion. Since these features are all susceptible to damage by grazing animals, the needs of the indigenous fishery and the stockman can conflict.

Presently, there is an unfortunate dearth of factual information regarding the impacts of livestock grazing on riparian and aquatic ecosystems. As yet, only limited research has been directed toward lessening these impacts, though the constant increase in range use by cattle since the late 1800's has generally degraded rangelands and led to altered riparian habitats (Platts 1978). The resulting controversy surrounding the use of public rangelands by livestock and its potential conflicts with fishery needs has led to the emergence of livestock management as a national environmental issue (Leopold 1975, Platts 1978).

Working in this information vacuum, fisheries biologists have intuitively hypothesized that grazing of the riparian zone can significantly alter a fishery. Such alteration is believed to occur through physical modification of key stream features. Such changes as increased channel breadth, decreased depth and pool-riffle ratio, loss of vegetative and structural cover, accelerated bank erosion and sedimentation, and increased water temperature are expected to modify the character of the fishery. These changes, however, have yet to be sufficiently evaluated and identified for routine inclusion in management strategies. Additional studies that will provide solutions to these potential problems must be conducted (Meehan and Platts 1978; Platts 1978).

Against this background of limited information, it should come as no surprise that little help can be given the land manager in determining alternate strategies in situations where livestock are known to be exerting undue stress on the fishery. Valid analytical techniques for assessing the magnitude of livestock impacts have yet to be fully developed. Without these tools, it is difficult to determine whether change in grazing patterns are indicated and what strategies should be implemented.

The Tabor Creek study is part of a comprehensive program to develop and test an array of field techniques which, when coupled with computerized analysis, will accurately identify the complex interactions that occur between different grazing intensities, grazing systems, classes of livestock, and fish. Field studies are currently being conducted on 11 sites in Idaho, 3 sites in Nevada, and 3 sites in Utah (figure 1). The Idaho studies monitor impacts to streams in moist, forested, high mountain meadows, while the Utah and Nevada studies monitor impacts to streams in the more arid, sagebrush-type meadows. These studies are structured to allow time-trend analysis of livestock impacts on streams and will help the land manager select grazing systems that are as compatible as possible with fishery needs.

This progress report deals exclusively with the Tabor Creek Study, which has the following objectives:

1. Determine the rehabilitation potential of Tabor Creek based on past, present, and future use strategies.

2. Evaluate the efficacy of excluding livestock from the riparian zone by studying protected habitat within fenced exclosures.

3. Evaluate the continuous (season-long) grazing system currently in use along Tabor Creek.

4. Evaluate a newly initiated rest-rotation grazing system on the riparian and fishery habitat of Tabor Creek.

5. Make recommendations as to the optimum grazing strategies relative to use and protection of riparian forage.

IDAHO BATHOLITH

1 SFSR - Lower Stolle
2 SFSR - Cougar Stolle
3 SFSR - Guard Stolle
4 SFSR - Upper Stolle
5 Johnson Creek
6 Elk Creek
7 Lower Bear Valley Creek
8 Upper Bear Valley Creek
9 Lower Frenchman Creek
10 Upper Frenchman Creek
11 Horton Creek

LAHONTAN BASIN

12 Gance Creek
13 Chimney Creek
14 Tabor Creek

BONNEVILLE BASIN

15 Lower Big Creek
16 Upper Big Creek
17 Otter Creek

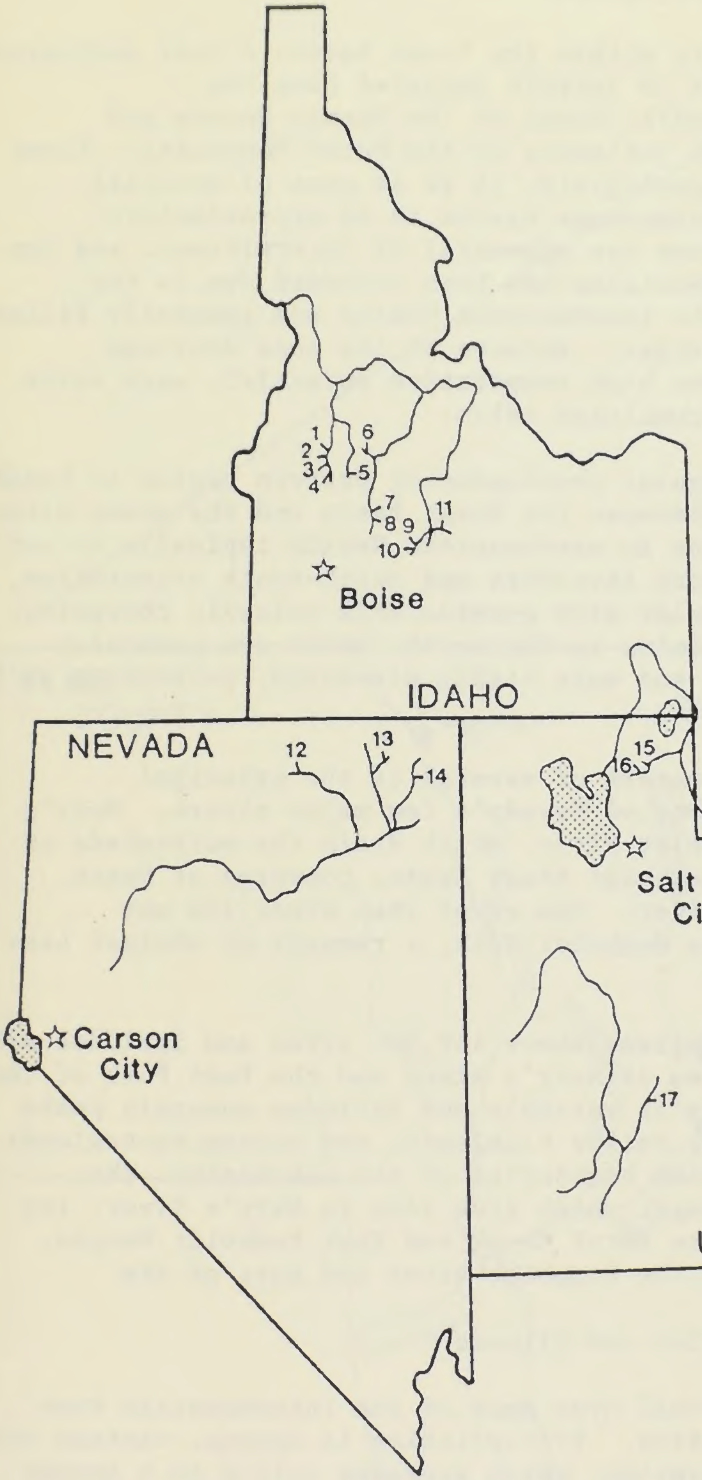


Figure 1. Geographic distribution of Livestock-Fishery Study areas in the Intermountain West.

STUDY AREA DESCRIPTION

Physiography

Most of the state of Nevada lies within the Great Basin, a vast semi-arid region of western North America that is largely isolated from the moisture-laden air masses of the Pacific Ocean by the Sierra Nevada and Cascade ranges, and from continental influence by the Rocky Mountains. Known as the Basin and Range Province by geologists, it is an area of parallel fault-block mountain ranges and intermontane basins in an approximately north-south orientation. Most streams are ephemeral or intermittent, and few drain to the sea. Erosion of the mountains has been retarded due to the shortage of precipitation, though the intermontane basins are generally filled with soil originating in adjacent ranges. Because of the poor drainage conditions of the Great Basin and the high evaporative potential, such soils typically contain high levels of accumulated salts.

In northeastern Nevada this regular physiographic pattern begins to break down. This is the transition zone between the Great Basin and the Snake River and Columbia Plateaus. The mountains in northeastern Nevada typically do not exhibit the characteristic fault-block structure and north-south orientation, but are instead dome-like and irregular with considerable volcanic character. In contrast to the extensive lava plains to the north, which are generally downwarped, this region is unwarped and more highly dissected, possessing well developed mountain ranges.

This region comprises the headwaters of several of the principal tributaries of the Humboldt River, one of Nevada's few major rivers. Mary's River and the East Fork of the Humboldt River, which drain the watersheds of the Mary's River sub-basin of the Humboldt River Basin, converge at Deeth, Nevada, to form the main Humboldt River. The river then winds its way generally westward to empty into the Humboldt Sink, a remnant of ancient Lake Lahontan, in western Nevada.

The Mary's River Sub-basin comprises about 469,800 acres and includes all the drainage areas of the tributaries of Mary's River and the East Fork of the Humboldt River (Fig. 2). Topography is variable and includes mountain peaks with elevations of over 10,000 feet, valley highlands, and stream bottomlands. Four mountain ranges form the highland boundaries of the sub-basin: the Jarbidge Mountains and the Snake Range, which give rise to Mary's River, its tributaries, and Tabor Creek; and the Burnt Creek and East Humboldt Ranges, which give rise to the East Fork of the Humboldt River and most of its tributaries.

Vegetation and Climate

Severe climatic conditions prevail over much of the Intermountain West and northeastern Nevada is no exception. Precipitation is sparse, winters are cold, and summers are hot. Precipitation, which averages only 8 to 9 inches at middle elevations, falls primarily as snow during winters in which the minimum January temperatures average only about 12°F (-11°C). The growing season is short, only about 3 months, and evaporation exceeds precipitation. Summer maximum temperatures average as high as 85°F (29°C), with minimal amounts of rain falling during this period; useable water during the growing season is chiefly derived from melting of the winter snowpack, and is

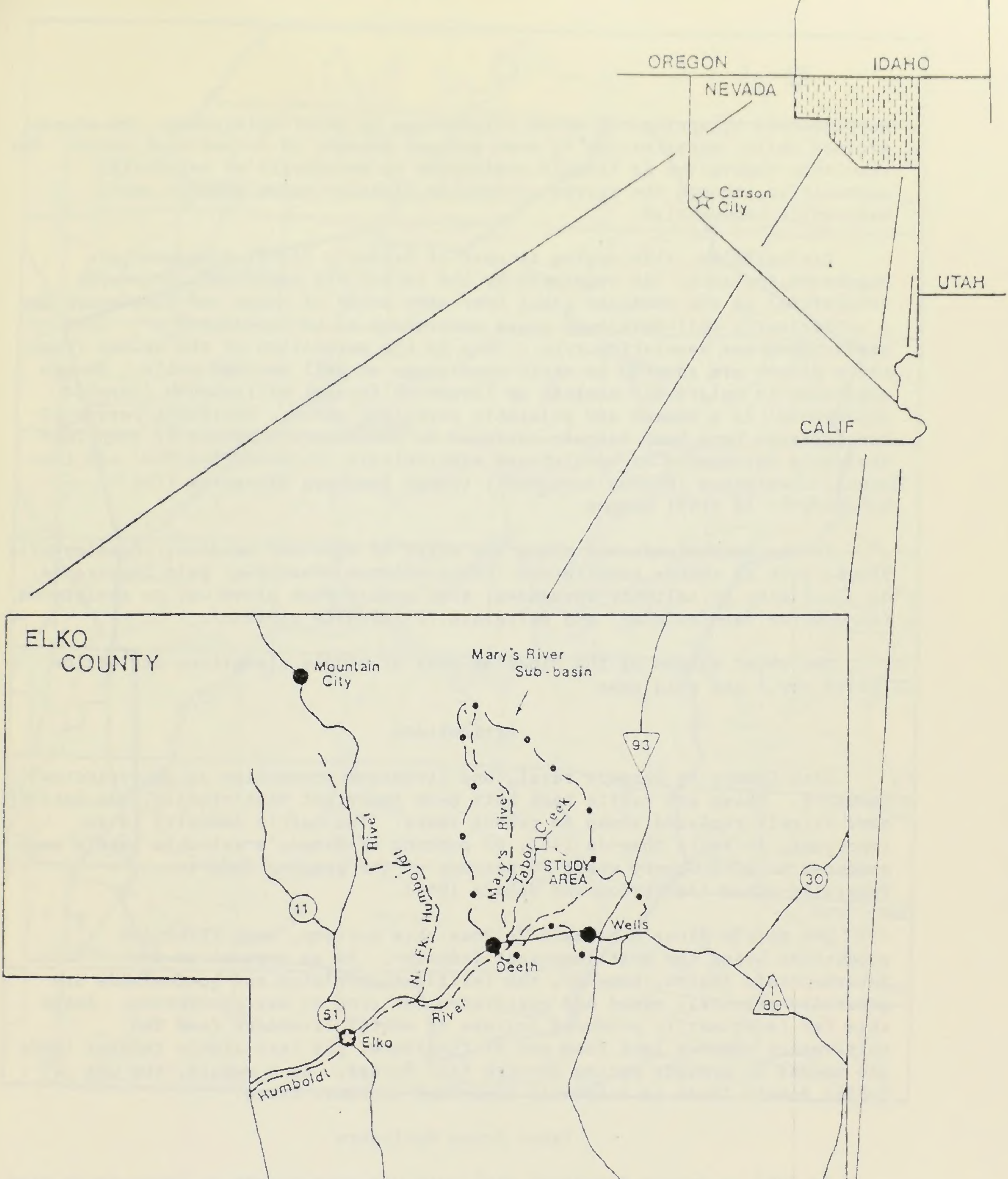


Figure 2. Location of Mary's River Sub-basin and the Tabor Creek study area.

supplemented by springs of water originating in other watersheds. On poorly drained soils, water stress is even greater because of accumulated salts. The resultant vegetation is largely restricted to xerophytic or halophytic communities, though the narrow streamside riparian zones support small mesophytic communities.

Ecologically, this region is part of Bailey's (1978) Intermountain Sagebrush Province. As suggested by the title, big sagebrush *(Artemesia tridentata)* is the dominant plant over many acres of range and frequently has a sufficiently well-developed grass understory to be considered a sagebrush-grass vegetation type. This is the vegetation of the upland range where plants are adapted to xeric conditions on well drained soils. Though sagebrush is relatively useless as livestock forage, bitterbrush *(Purshia tridentata)* is a common and palatable associate shrub. Desirable perennial bunchgrasses have been largely replaced in northeastern Nevada by such less desirable increasers as bottlebrush squirreltail *(Sitanion hystrix)* and the annual cheatgrass *(Bromus tectorum)*, though Sandberg bluegrass *(Poa sandbergii)* is still common.

In the bottomlands and along the edges of semi-wet meadows, phreatophytic shrubs such as rubber rabbitbrush *(Chrysothamnus nauseosus)* gain importance. As alkalinity or salinity increases, even rabbitbrush gives way to greasewood *(Sarcobatus vermiculatus)* and saltgrass *(Distichlis stricta)*.

The chief shrubs of the riparian zone at middle elevations are willow *(Salix spp.)* and wild rose.

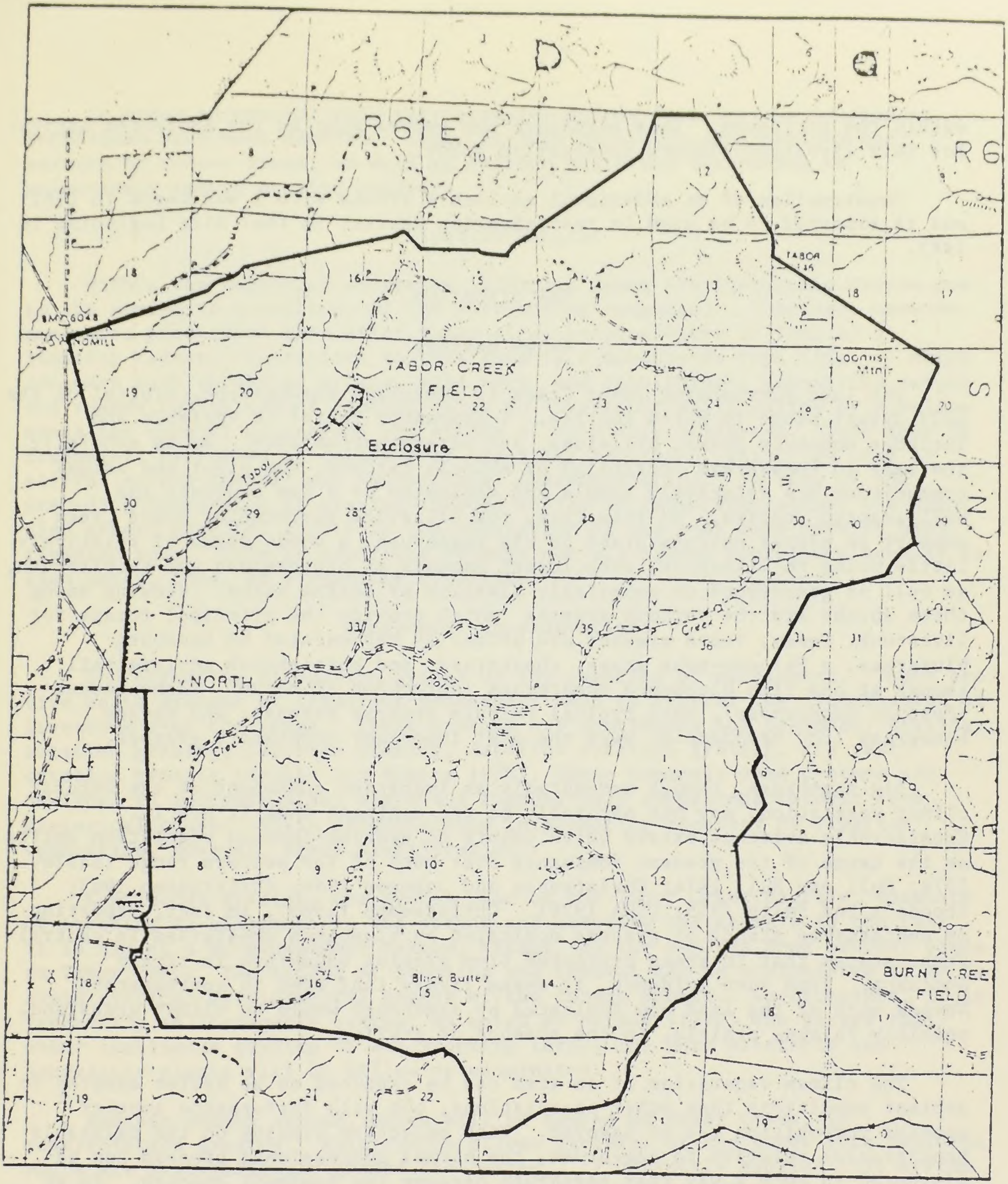
Agriculture

Elko County is largely rural, and livestock production is the principal industry. Sheep and cattle have both been important historically, but cattle have largely replaced sheep in recent years. The cattle industry is so important, in fact, that in 1961, 62 percent of Nevada's saleable cattle were produced in Elko County where 86 percent of the grazing land is federally-owned (Patterson and others 1969).

The Mary's River Sub-basin follows this pattern, with livestock production being the most important industry. As is typical in the intermountain region, however, the fertile floodplains and bottomlands are generally privately owned and cultivated for crop or hay production. Since this hay is primarily produced for use as winter livestock feed and cultivation removes land from use by livestock, the less arable federal lands are needed to provide spring through fall forage. As a result, the use of public domain lands is a locally important economic issue.

Tabor Creek Exclosure

In 1968, a fenced livestock exclosure was constructed on Tabor Creek near the northern limit of the Tabor Creek field (Fig. 3) to protect sage grouse *(Centrocercus urophasianus)* habitat from livestock damage. Prior to the fall of 1976, however, the gates were left open and grazing was essentially unrestricted; since closing the gates in 1976, no known grazing has occurred



igure 3. Tabor Creek Field and location of the livestock exclosure.

within the exclosure. This structure now serves also as the protected habitat for this livestock-fishery interaction study.

Construction of an additional exclosure around site 1 was begun in 1981 and is expected to be used to rest riparian habitat in that site beginning in 1983.

THE SITUATION

Range Habitat

The land surrounding Tabor Creek is semi-arid shrubsteppe, typical of the cold desert biome in North America. Topographic relief is variable and includes mountain peaks, hillsides, and stream bottomlands. As is generally the case in ecosystems controlled by abiotic factors, the plant and animal communities are relatively simple and dominated by a few abundant and well-adapted species. In this case, the hillsides surrounding Tabor Creek support an almost uniform stand of big sagebrush, a woody shrub of relatively little value to livestock, with lesser amounts of bitterbrush and rabbitbrush, as well as greasewood on especially alkaline or saline sites. Growing among these shrubs are the various grasses which provide the principal forage for livestock. Today, these grasses are primarily represented by Sandberg bluegrass, a Palouse-type grass, cheatgrass, and bottlebrush squirreltail though at one time bluebunch wheatgrass *(Agropyron spicatum)*, Idaho fescue *(Festuca idahoensis)*, both typical Palouse prairie grasses, and Nevada bluegrass *(Poa nevadensis)* were the most important understory grasses.

Big sagebrush, though undoubtedly an important component of the natural climax vegetation, may not naturally be the dominant that it now is. Considerable evidence exists which points to grazing-induced vegetation shifts as the cause of its present dominance over much of the western range (Bailey 1978; Hull and Hull 1974; Christensen and Johnson 1964; Christensen 1963; Stoddart and Smith 1955; USDA 1936). Christensen (1963), in fact, reporting on undisturbed stands of grasses dominated by bluebunch wheatgrass in central Utah, states that in areas protected from grazing sagebrush is rarely dominant. From such evidence, it seems likely that even in northeastern Nevada much of the land now dominated by sagebrush would be climax grassland, possibly Palouse prairie, in the absence of grazing.

The climax vegetation of an area can be expected to be better adapted to ambient conditions than other associations, but with disturbance another species composition may be favored. With selective grazing on the palatable bunchgrasses relative to sagebrush, the normal successional process can be disrupted in such a way that sagebrush becomes the dominant species. In an area that has been historically heavily grazed, this shift toward sagebrush dominance should be expected, as should be the invasion or proliferation of other species favored by grazing conditions. One such grass is the increaser cheatgrass, which is common in Elko, County, and is a relatively undesirable annual grass. Through these processes the quality of the range deteriorates in response to grazing pressure and the big sagebrush type is maintained as a grazing disclimax.

In order to control this retrogressive succession, various management techniques have been devised. These include herbicide applications and burning to reduce brush, as well as various pasturing techniques to selectively reduce grazing pressure.

Riparian Habitat

Within the sagebrush ecosystem, riparian zones are frequently narrow due to the semi-arid conditions of the surrounding rangeland. They are, however, much more productive than drier range sites because water is less of a limiting factor. Vegetation in this zone is a mesophytic type (Fig. 4) which includes such shrubs as willow, wild rose, and rabbitbrush; grass-like sedges and rushes, which are of limited value to livestock; while saline or alkaline areas may support greasewood and stands of palatable saltgrass. This zone is frequently preferred by cattle over the drier rangeland, which can lead to altered stream channel and vegetational characteristics. In view of the preceding discussion of grazing-induced shifts in range vegetation, one might also expect parallel shifts in the vegetation of the even more heavily used riparian zone. This is important because not all plants contribute equally to fish cover, food, or streambank stability.

Management Considerations

The preceding discussion brings up the question of management. There are five basic systems of livestock management used to control the distribution of livestock over the range. These systems are continuous (or seasonal) grazing, rotation grazing, deferred grazing, deferred rotation grazing, and rest rotation grazing (Meehan and Platts 1978). These commonly used systems are designed to increase plant vigor and thereby help rangelands recover from historical abuse. Their effectiveness in promoting recovery of riparian vegetation, however, needs clarification.

Continuous grazing, the system used on the Tabor Creek pasture, consists of stocking an allotment in the spring and removing the animals in the fall. It is almost a no-management system, except, as the BLM has done several times on Tabor Creek, the timing of stocking and removal can be manipulated so as to avoid critical developmental stages of the forage plants. Nevertheless, it is frequently an inadequate system, as noted by Hormay (1970) who states that under continuous grazing at any stocking level, the more palatable and accessible plants will be killed or eliminated.

Another common system, which will be tested on Tabor Creek, is rest-rotation grazing. This system allows division of the range into pastures which are systematically grazed and rested. If correctly applied this system can help restore the vigor of range plants, providing that the amount of rest required is determined by the phenology of the plants involved (Hormay 1970). Whether this system can benefit riparian vegetation, however, is still open to question and there are, in fact, indications that it cannot help the recovery of abused riparian habitat. Meehan and Platts (1978) suggest that this system may be harmful to riparian ecosystems because of increased potential for livestock movement in and use of the riparian zone, so studies such as this one are necessary for conclusions to be drawn.

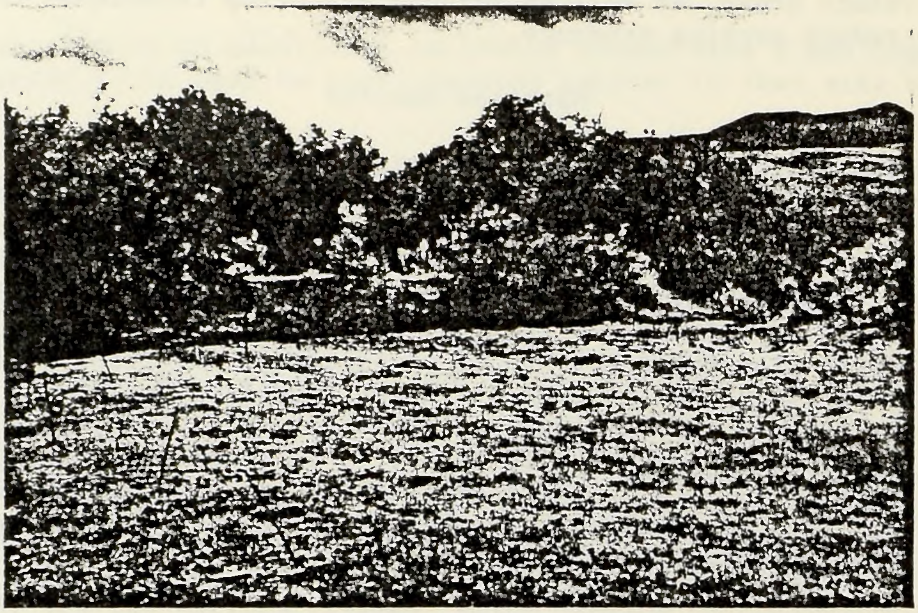


Figure 4. Riparian vegetation along Tabor Creek, Elko County, Nevada.

The three other systems either defer grazing for parts of the season or combine seasonal deferment and resting. None have clearly been shown to be effective in helping to rehabilitate riparian vegetation though some may be more successful than others. Only one strategy clearly stands out as being useful in riparian recovery: complete rest. This can be accomplished by fencing, which the BLM has done with the Tabor Creek exclosure, and, though it cannot be the final solution, it must be a consideration if high quality riparian habitat is to be conserved. The answer to this vexing problem should become clear as this study progresses since it will compare the effects of several grazing strategies.

GRAZING PATTERNS

History

Prior to the discovery of gold in California in 1849, Nevada had remained largely unsettled, a vast expanse of mountain ranges and basins, belonging first to Mexico and acquired by the United States in 1848. Cattle were first brought into the state in the early 1840's, but these were few and largely passing through with parties of settlers and explorers. With the discovery of gold in California, however, large numbers of fortune seekers from the East found good passage along the course of the Humboldt River. This emergence of the Humboldt River as a major route to the gold fields led to the need for way-stations and settlements along this, the principal river in northern Nevada. With the local settlers came livestock and the first herds were loosed upon northeastern Nevada's virgin grasslands, giving birth to one of the states most important industries.

Early grazing use was extremely heavy, with itinerant bands of cattle and sheep competing with local ranchers for the desirable forage, and as late as 1880 there was still no law in Nevada that defined a "lawful fence." The problem of range abuse was recognized, however, and in 1909 a section of the Jarbidge Mountains, including the headwaters of Mary's River, was added to the Humboldt National Forest to protect important watersheds in these mountains. Extensive tracts of public land still remained open to unregulated use including most of the Mary's River Sub-basin, so, in 1919, Nevada enacted legislation requiring stockmen to own land before they could graze public range; this law was later repealed. Conditions continued to deteriorate as desirable forage was severely reduced or eliminated and undesirable species gained prominence. The problem on western rangelands was so severe that the federal government intervened again in 1934 with passage of the Taylor Grazing Act. This Congressional Act created the Grazing Service (later combined with the General Land Office to create the BLM) in the Department of the Interior to regulate grazing on public domain lands.

During the 90 years of grazing prior to formation of the Grazing Service, records of actual use by operators were inadequate. Thus, despite the fact that herds were taxed and fees were required to use lands set aside in national forests, it is difficult to accurately estimate how heavy use was in the Mary's River Sub-basin. Some insight into this question can be gained by considering the size of the cattle operation run in Elko County by John Sparks and A. J. Harrel, incorporated as the firm of Sparks and Harrel. With their headquarters in Wells, Nevada, they owned 200,000 acres from Wells north to the Snake River and in 1884 branded 14,000 calves; their breeding herd in Elko

County numbered some 70,000 animals (Hazeltine and others, 1965). This firm, though definitely the largest in Elko County, was only one of several very large operations which, when considered with the many itinerant and tramp herds in the area, paint a picture of a severely overstocked range with little effective regulation outside of national forest reserves.

The more recent records used for adjudication under the Taylor Grazing Act are more accurate and indicate that during the period 1929-1934 the area from Mary's River to the crest of the Snake Mountains and from the Humboldt River to Hot Creek on the north (approximately the eastern three-fourths of the sub-basin and including Tabor Creek, figure 2) domestic livestock numbers were on the order of 27,000 annually. Such heavy use indicates that the range continued to be overused and, though the Grazing Service did much to ameliorate range conditions, range quality continued to decline. As a result, the Metropolis Unit, which comprised this part of the sub-basin, was adjudicated in 1957 and the BLM imposed a 39 percent reduction in use over the succeeding three years.

In 1958 the BLM consummated a land exchange with Marble Ranches (Mary's River Ranch) which placed the upper portion of the Tabor Creek watershed under private ownership; commencing approximately 1 July, this area has been grazed every summer since.

Present and Future Trends

Grazing by allotment, an arrangement in which certain range subdivisions are designated for use by authorized operators, was instituted in the Tabor Creek area in 1961. The BLM land along Tabor Creek, along with that along Burnt Creek, was placed in the Barlow area of use. Season-of-use dates were then set in 1965, designating these two pastures as summer range with a season-of-use from 1 June to 15 September; stocking of the Tabor Creek field was set at 1,350 head for 4,725 animal unit months (AUM's). As can be seen in table 1, this pattern was modified prior to the 1970 grazing season with permitted use increased to 1,350 head for 4,865 AUM's. During the 1970's the pattern fluctuated with the permitted stocking level being raised to 2,122 head for 7,639 AUM's accompanied by a season-of-use change to the period 1 July to 20 October, and in 1979 the turn-off date was pushed up to 30 September reducing use to 6,366 AUM's; at all times, use remained below the estimated carrying capacity of 8,100 AUM's. This general pattern is expected to continue, with the possibility of some reductions in animal numbers.[1/] Grazing did not occurred within the exclosure on Tabor Creek between the fall of 1976 and spring 1982.[2/]

[1/] Crispin, Val. 1980. Personal correspondence. USDI Bur. Land Manage., Elko, Nevada.

[2/] Although the exclosure was opened to allow grazing in 1982, the fence for the new exclosure was not completed prior to the grazing season and use occurred in site 1.

Table 1.--Actual and projected management, Tabor Creek Pasture, 1973-1983 (targeted values parenthetical).[1]

Grazing parameter		Year										
		1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Estimated capacity (AUM's)		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Stock class		cattle	cattle	cattle	cattle	cattle	cattle	cattle	cattle	cattle	cattle	cattle
Grazing system		PWC[2]	PWC	PWC	PWC	PWC	PWC	PWC	PWC	PWC	PWC	PWC
Grazing season		6/1 - 9/15	6/1 - 9/15	6/1 - 9/15	6/1 - 9/15	6/1 - 9/15	7/1 - 10/20	7/1 - 9/30	7/1 - 9/30	7/1 - 9/30	7/1 - 9/30	7/1 - 9/30
Permitted stocking level	(Numbers)	1390	1390	1390	1390	1390	2122	2122	2122	2122	2122	2122
	(AUM's)	4865	4865	4865	4865	4865	7639	6366	6366	6366	6366	6366
Actual[3] stocking level	(Numbers)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	(AUM's)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Range vegetation use (percent)[4]		N.D.	N.D.	N.D.	N.D.	24	29	N.D.	37	N.D.	28	N.D.
Riparian[5] vegetation use	Inside orig. Exclosure	N.D.	N.D.	N.D.	N.D.	0	0	0	0	0	70	(80)
	Outside orig. Exclosure	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	68	70	64	74	N.D.[6]

[1] Data supplied by Val Crispin, BLM, Elko, Nevada, unless otherwise noted.

[2] Pasture-wide continuous.

[3] Where no data are available, actual use must be assumed to equal permitted use.

[4] Raw use data provided by Roy Masinton, BLM, Elko, Nevada; determined by key species method for a nearby upland range site.

[5] Refer to Table 3 (average of sites 1 and 3).

[6] Will be zero in site 1.

Beginning in 1982, a new series of grazing treatments are scheduled for the Tabor Creek Study area. A new exclosure was constructed to rest the riparian zone in site 1 and a modified rest-rotation system (Fig. 5) was initiated within the original, previously rested exclosure. This rest-rotation system will involve the stocking of 21 cattle for 2 months (72 AUM's), according to the following plan:

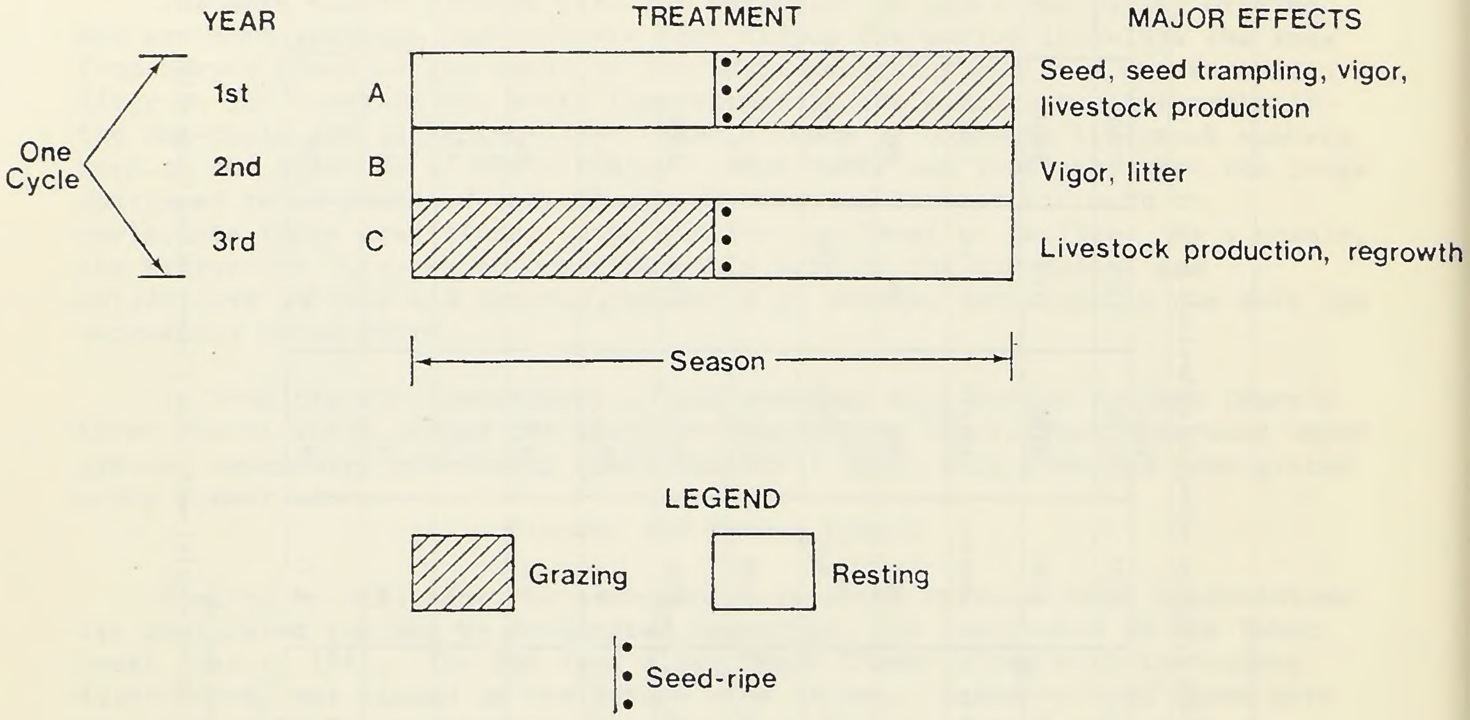


Figure 5. Rest-rotation strategy to be applied in the existing livestock exclosure beginning in 1982.

METHODS

General

Ongoing studies are presently being conducted on a total of 15 study sites, 11 in Idaho and 3 each in Nevada and Utah. These sites are generally in meadow environments on National Forest lands, and lower elevation sagebrush-type meadows on Bureau of Land Management lands. The purpose of these studies is to refine techniques for monitoring and assessing the impacts of livestock on riparian and aquatic ecosystems.

The basic design of each study site is to stratify 1800 feet of stream by subdividing it into 181 transects placed at 10-foot intervals along the stream. The stream is then divided into three 600-foot sections, with the middle section fenced to provide an area for manipulation, the up- and downstream sections serving as controls. Livestock are either introduced to or excluded from the fenced area depending on the needs of the study. Annual monitoring of each section then provides information on each relative to the others over the course of several seasons of use. For Tabor Creek, this basic design has been modified, to accommodate the large size of the exclosure and to allow two grazing treatments (complete rest and a rest-rotation strategy (Fig. 6).

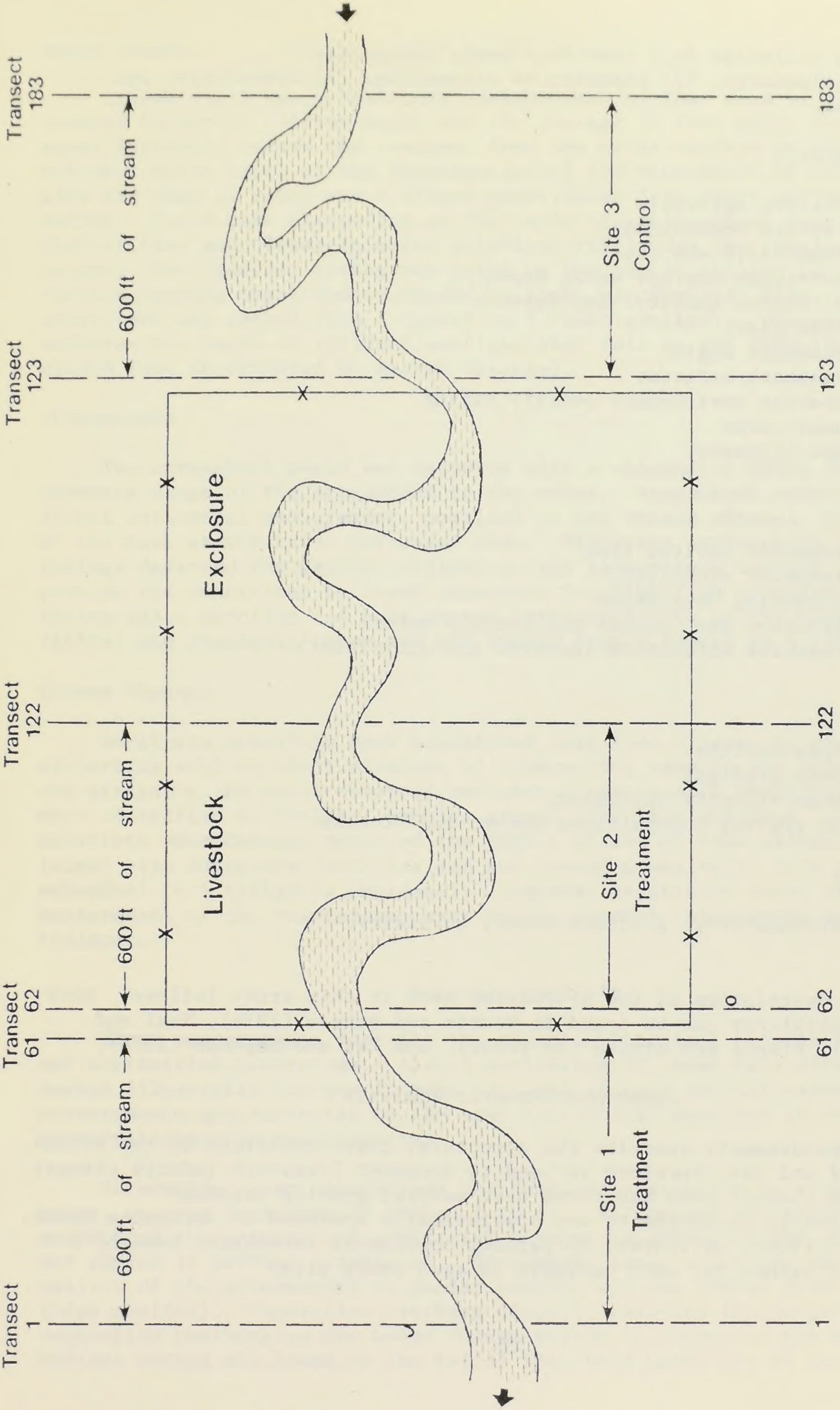


Figure 6. Schematic diagram of the study design used on Tabor Creek.

The data collected fall into four basic categories: (1) geomorphic/aquatic, (2) riparian or streamside, (3) hydrologic, and (4) biological.

Geomorphic/Aquatic

1. Substrate materials
2. Substrate embeddedness
3. Stream width and depth
4. Bank-stream contact water depth
5. Pool width, quality, and feature
6. Riffle width
7. Streambank angle
8. Streambank undercut
9. Fisheries environment quality rating
10. Canopy cover
11. Light intensity

Riparian

12. Streamside habitat type
13. Streambank stability
14. Overhanging vegetation
15. Vegetation use (ocular and herbage meter)
16. Streambank alteration (natural and artificial)

Hydrologic

17. Stream profile
18. Stream gradient
19. Stream velocity Biological
20. Fish species composition, number and biomass

Water/quality

21. Hydrochemistry, coliform count, turbidity.

A brief description of the procedures used in this study follows. More detailed descriptions can be found in Morris and Others (1976), Neal and Others (1976), Platts and others (in press), and Ray and Megahan (1978).

Geomorphic/Aquatic Analysis

These measurements describe the structural characteristics of the stream being studied and can therefore be used to document livestock induced changes in the stream channel when monitored over several grazing seasons. Geomorphic/aquatic measurements are statistically analyzed to determine means, standard deviations, variances, 95 percent confidence intervals, Student's t values, and F values for each variable in each study site.

Water Column

Stream width was a horizontal measurement of that area of the transect covered by water. Stream depth was the average of four water depths taken at equal intervals across the transect from the water surface to the channel bottom. Water depth at the intersection of the streambank or stream channel with the edge of water was a direct measurement from water surface to channel bottom. Pools were classified as that area of water column usually deeper than riffles and slower in water velocity; riffle was the remainder of the column. Pool quality rating was based on the pool's ability to provide certain rearing requirements needed by fish, particularly size, depth and cover, and was ranked from 1 (poor) to 5 (high quality). Canopy cover measures the angle of incident sunlight that fell on the midpoint of the stream (not intercepted by nearby objects).

Streambanks

The streambank angle was measured with a clinometer which determined the downward slope of the streambank to the water. Streambank undercut was a direct horizontal measurement, parallel to the stream channel, of the erosion of the bank at the water influence area. Fisheries environment quality ratings depicted the general ability of the bank-stream contact zone to provide the conditions believed necessary for high fish standing crops. This rating was a function of both stream characteristics at the bank (pool or riffle) and available cover and was ranked from 1 (poor) to 5 (excellent).

Stream Channel

Substrate materials were classified into five classes by visually projecting each one-foot division of a measuring tape to the streambed surface and assigning the major observed sediment class to each division; sediments were classified as boulder, rubble, gravel, and fine sediment. Stream channel substrate embeddedness measured the gasket effect of fine sediment around the larger size substrate particles and was ranked numerically from 1 (highly embedded) to 5 (slightly embedded). Instream vegetation cover was a direct measurement of the vegetative cover on the channel intercepted by the transect.

Riparian Analysis

These measurements describe the riparian interface between the aquatic and terrestrial ecosystems. Annual monitoring of these data after the grazing season illustrates changes in many critical fishery habitat parameters. These measurements are subjected to the same statistical analyses as the geomorphic/aquatic measurements.

Streamside cover categorized the dominant vegetation as exposed, brush, grass, or tree (numerically ranked 1 to 4). Streambank alteration assessment quantified the natural and artificial changes occurring to the streambank and was ranked in percent alteration. Streamside cover stability rated the ability of the streambanks to resist erosion and was ranked from 1 (poor) to 4 (high quality). Vegetative overhang directly measured the length of the vegetation overhanging the water column within 12 inches of the water surface. Habitat rating was based on the belief that sand banks are of least importance to fish, while brush-sod banks are of the greatest value; intermediate types were ranked accordingly by dominant and subdominant characters. Measurement of vegetation use was done both by ocular assessment and with an herbage meter.

Streamside Herbage Analysis

In order to provide a quantitative complement to an ocular vegetation use assessment, a Neal Electronics Model 18-2000 or 18-3000 herbage meter was used to measure standing vegetation. These readings were taken at approximately every fourth transect, and linear regression analysis against clipped plots provided a quantitative measure of forage biomass and use.

Fish Population Analysis

Fish populations were sampled with either battery powered, portable, backpack mounted electrofishers or with gasoline powered, motor energized units. Salmonids were counted, measured, and weighed, while non-salmonids were counted and weighed as a group. All were handled as carefully as practicable, and promptly returned to the stream alive.

Hydraulic and Channel Geometry

Ten transects in the central section of each 600-foot stream reach were used for hydraulic geometry measurement; the data obtained here allow us to generate a channel cross-section map and periodic measurement over the course of the study shows quantitative changes due to erosion and deposition of channel materials. The streams were surveyed to detect changes in their relative positions, and the water surface was surveyed to allow monitoring of changes in channel gradient.

Water Quality Analysis

This topic was not addressed in Progress Report 1 because it is not a regular component of our battery of measurements. We have received Tabor Creek water quality data from the BLM and are including it in this report because it is useful in characterizing the aquatic habitat of Tabor Creek.

Water quality sampling was performed at three locations on three dates in 1979 and three dates in 1980. One sampling site was located two miles below the study area; the second was in the study area immediately above the livestock exclosure; and the third was three-fourths of a mile above the study area. Sampling was conducted in 1979 on 8 May, 24 July, and 18 September; and in 1980 on 1 May, 15 July, and 24 September. This spatial and temporal distribution of sampling provides a picture of the changes in water quality along the stream reach as well as annual and seasonal fluctuation.

RESULTS AND DISCUSSION

Geomorphic/Aquatic Analysis

The first livestock exclosure (surrounding site 2), which has been functional since 1976, was opened in 1982 to permit livestock grazing on the early cycle of a rest-rotation strategy. The second exclosure (surrounding site 1) was scheduled for completion in time for the 1982 grazing season, but was not completed in time to prevent livestock use in the site 1 riparian zone. Habitat conditions in site 2 were sufficiently superior to those of the other two sites to warrant the conclusion that the rehabilitative process was well underway, despite the lack of before the fact data. Construction of the new exclosure will allow observation of rehabilitation with substantial before the fact data, while grazing in the first exclosure will allow observation of the effects of renewed livestock use and rest-rotation grazing on Great Basin streamside habitat that has been rehabilitating itself. Comparison of the rehabilitation process in site 1 and of rest-rotation grazing in site 2 with the no change situation in site 3 will help determine the best grazing systems for Great Basin streams.

Time trend plots and results by year with confidence statistics are presented in Appendixes 1 and 2, respectively.

Water Column

Tabor Creek has consistently been narrowest and deepest in previously rested site 2 (Table 2), which was expected from the hypothesis that grazing widens stream channels by bank trampling and accelerated erosion. Effects of the increased streamflow in 1982 were evidenced by increases in stream widths and depths in all sites, with the exception of average depth in site 1. Interestingly, the increase in width was proportionally much greater in site 2, though similar differential increase occurred in the wet year of 1980; it is therefore unlikely that this phenomenon was due principally to renewed grazing in site 2.

The abrupt changes in the relative abundances of pool and riffle areas in 1982 cannot be readily explained by real events. These are very subjective measurements, and it is likely that the abrupt increase in the abundance of pool (and decrease in riffles) resulted from observer bias coupled with the need to classify all uncertain areas as pools. These factors confound evaluation of interyear differences, but should not materially affect intrayear comparisons; therefore, it seems likely that site 2 has consistently had the greatest amounts of pool, and that pool areas may even be increasing in abundance in site 1. Observer bias probably also caused the increased pool ratings in each site in 1982, but it is nevertheless clear that site 2 had the highest quality pools, and their quality apparently did not decline with the renewal of grazing in 1982.

The rating scale for pool feature evaluation was modified in 1981, so results of the first two years are not directly comparable to the latter two years. The former scale consisted of only two ranks, 1 for no beaver influence and 9 for beaver influence; the pool feature ratings, therefore, show the presence of beaver activity in pool formation in site 2 only. The 1981-82 scale included more parameters in pool formation, some of which were

Table 2.--Summary of annual geomorphic/aquatic and riparian analysis means, Tabor Creek, Nevada.

	Study Site											
	Site 1				Site 2				Site 3			
Variable	1979	1980	1981	1982	1979	1980	1981	1982	1979	1980	1981	1982
Geomorphic/Aquatic												
Water Column												
Stream width (ft)	13.9	14.6	13.6	14.6	10.3	11.7	10.8	12.5	12.3	12.8	12.4	13.1
Stream depth (ft)	0.33	0.32	0.35	0.34	0.43	0.43	0.43	0.44	0.37	0.37	0.35	0.37
Riffle width (pct)	81.4	76.5	72.3	46.4	78.6	63.0	71.9	29.1	85.5	62.3	80.3	38.1
Pool width (pct)	18.6	23.5	27.7	53.6	21.3	37.0	28.2	70.9	14.4	37.7	19.7	61.9
Pool feature	1.0	1.0	3.7	4.6	1.6	1.3	4.7	6.5	1.0	1.0	3.8	4.6
Pool quality rating	1.3	1.5	1.6	2.8	1.8	2.0	2.0	3.0	1.4	2.0	1.8	2.8
Canopy cover (deg)	N.D.	N.D.	123	110	N.D.	N.D.	131	125	N.D.	N.D.	119	95
Light intensity (pct)	N.D.	N.D.	N.D.	48	N.D.	N.D.	N.D.	48	N.D.	N.D.	N.D.	30
Streambanks												
Bank angle (deg)	114	128	133	129	110	116	121	128	111	125	125	124
Bank undercut (ft)	0.13	0.12	0.10	0.14	0.18	0.18	0.11	0.11	0.13	0.13	0.20	0.20
Bank-water depth (ft)	0.15	0.08	0.03	0.22	0.07	0.12	0.09	0.12	0.10	0.08	0.07	0.13
Fisheries rating	1.3	1.3	1.5	1.9	1.7	1.5	2.2	2.2	1.4	1.6	2.0	2.2
Streambottom												
Fines <0.03 in. (pct)	11.0	7.8	4.8	6.6	16.8	9.5	8.1	7.1	8.0	8.6	4.9	4.1
Fines >0.03 in. (pct)	2.9	1.1	0.2	1.7	5.5	1.5	0.2	4.8	3.1	0.4	0.4	4.1
Gravel (pct)	50.2	41.0	53.4	48.9	45.3	52.0	43.7	49.5	58.9	57.7	39.6	49.5
Rubble (pct)	31.1	47.9	38.2	38.3	20.1	27.7	36.3	27.1	22.6	27.9	48.2	37.0
Boulder (pct)	4.8	2.2	3.2	4.5	12.3	9.4	10.1	11.5	7.6	5.5	7.0	5.3
Substrate embeddedness	3.3	3.5	3.7	3.0	2.8	3.2	3.7	2.9	3.7	3.5	4.0	3.1
Instream vegetal cover (ft)	0.2	0.4	0.3	0.5	0.7	0.7	0.1	0.9	0.4	0.2	0.5	0.4
Riparian												
Habitat type	13.7	11.5	13.7	15.1	13.0	12.2	14.4	14.0	13.1	11.1	13.6	16.0
Bank cover stability	1.7	2.2	1.8	1.8	2.3	2.5	2.5	2.0	1.9	2.5	2.2	2.1
Stream cover	2.0	1.9	1.8	1.7	2.0	2.0	2.1	1.6	2.1	1.9	1.9	2.1
Vegetative overhang (ft)	0.11	0.04	0.10	0.16	0.42	0.46	0.53	0.28	0.26	0.16	0.11	0.53
Bank alteration (pct)												
natural	22	39	58	57	27	43	29	44	24	35	37	30
artificial	14	17	9	8	7	0	8	12	11	18	15	20
total	36	56	67	65	34	43	37	56	35	53	52	50
Vegetation use (pct)	68	72	65	85	0	0	0	70	68	67	63	63

combined in 1982, so even these figures are not precisely comparable. However, the ratings show that beaver, along with channel and bank structure, were to be important in site 2, whereas stream channel features were most important in the other two sites.

Canopy cover and light intensity are two recent additions to our array of measurements, and much interpretation of them would be premature at this time. Both measurements agree, however, that the water column in site 3 receives the least solar radiation, whereas the amount of insolation in sites 1 and 2 are probably similar.

Streambanks

Inspection of the changes in streambank variables in 1982 does suggest that some impacts of cattle grazing occur quickly. Streambank angle increased only in site 2 and was actually greater than the average bank angle in site 1 and nearly the same as that in site 3 for the first time during the study. This result would be expected if overhanging streambanks were beginning to be modified, and, indeed, the amount of undercut increased in sites 1 and 3, but decreased in site 2; the increases in sites 1 and 3 are probably due to apparent streambank changes and angle selection by the observer because of the high water level. Bank-water depth would also expect to decrease with bank modification; however, bank-water depth increased in all three sites, probably because of the increased water level, but the increase was very slight in site 2. The fisheries rating evaluates the quality of the streambank-water contact zone with respect to the needs of salmonids, but it is a somewhat subjective measurement; however, the fact that fisheries ratings in sites 1 and 3 were higher in 1982, while being unchanged in site 2 is further indication that the streambanks in site 2 may already show the effects of renewed cattle grazing.

Streambottom

The surface substrate conditions are quite good throughout the study area, and there is no clear pattern to the fluctuations in surface sediments over time. Fine sediments seem to have been generally declining in the study area prior to 1982, at which time they increased in somewhat in all three sites. This resulted primarily from an increase in large fine sediments, and in sites 2 and 3 the small fine sediments continued to decline. The chief consequence of this process was an increase in substrate embeddedness in all three study sites. Gravel decreased in sites 1 and 2, but increased in site 3 in 1982, suggesting that this upstream site may be the first place in the study where gravel transported from upstream begins to settle out of the water column. Of course, observations were not made during peak discharge, which can conceivably be greater in a low water year than a high water year depending upon such factors as rain or snow events, timing of precipitation, and air temperatures during snowmelt, so measurement of surface sediment composition during stable flows is inconclusive in this regard. No impacts of renewed grazing can be detected from these parameters, though they are probably most influenced by offsite events that cannot be controlled by fencing a small length of stream.

Instream vegetal cover increased in 1982, but, as in each year of the study, was not very abundant, never averaging more than 7 percent of the average stream width.

Riparian Analysis

The riparian analysis measurements (Table 2; Appendixes 3 and 4) are among the most subjective in our array of measurements, so a certain amount of observer bias is inevitable. Over time, however, the importance of such bias is reduced as trends become apparent. In the case of habitat type evaluation on Tabor Creek, for example, the coordinated fluctuations shown in the graph in Appendix 3 are probably the result of observer bias, whereas the uncoordinated decline in the habitat type rating in site 2 in 1982 is likely to represent a real change relative to the other two sites. Just such a change was expected from the hypothesis that changes in vegetation due to livestock grazing or rest should proceed more rapidly than stream structural changes. In this case, it appears that renewed cattle grazing has quickly affected the streambank habitat through vegetative changes. This conclusion is supported by similar relative changes in bank cover stability and stream cover ratings and by vegetation coverage measurements in site 2 in 1982. The decline in both stream cover and bank cover ratings was due largely to an increase in the amount of bare ground in site 2 and reduction in the amount of brush on the streambank was important in depressing the stream cover rating.

Most riparian parameters, with the exception of habitat type and artificial alteration, have consistently been better in site 3 than in site 1; all have, of course, consistently been best in site 2, with the sole exception of natural bank alteration. The high bank alteration in site 2, however, can be explained by the fact that we try to avoid bias in artificial alteration by classifying alteration of uncertain origin as natural; therefore, artificial alteration in site 2 was probably underestimated by classifying some as natural, and site 2 has, indeed, consistently displayed the least total alteration. The generally lower level of vegetation use by livestock in site 3 has possibly resulted in the somewhat better riparian conditions in that site relative to site 1, a thesis that is corroborated by the fact that site 3, for the first time, had a better habitat type rating than site 1 in 1982 when use in site 1 was exceptionally high.

Streamside Herbage Analysis

Despite the streamside heterogeneity of Tabor Creek with respect to the distribution of riparian species and encroachment by terrestrial species we again obtained a very good coefficient of determination (R^2) in 1982 (Table 3). The standard errors of estimate, which appeared to increase during the more productive (wetter) periods (see also Appendix 5), reflect the variability of the vegetation, but, with the exception of the 1980 results, are within the range reported by Neal and others (1976) for terrestrial rangeland. Furthermore, we believe that such variability is unimportant with respect to adequacy of the production and use estimates when both grazed and ungrazed sites are similarly heterogeneous and R^2 values are high (greater than about 0.75).

Unfortunately, there was no ungrazed study site in 1982 from which to obtain an available biomass estimate, so we could not estimate vegetation use by this method in 1982. It can be seen from table 4, however, that use in site 2 was less than in site 1 because the remaining biomass is greater; this result is in agreement with the visual estimates reported in table 1.

Table 3.--Annual streamside herbage analysis calibration results (gram equivalents are given parenthetically), Tabor Creek, Nevada; equations are of the linear form y = a + bx.

Year	Sample Size (n)	Constant (a)	Regression Coefficient (b)	Coefficient of Determination (r^2)	Standard Error of Estimate (Sy.x)
1979	16	-0.311 (-8.81)	0.074 (2.11)	0.89	0.52(14.64)
1980	14	-0.102 (-2.81)	0.087 (2.45)	0.89	1.09(30.19)
1981	16	-0.118 (-3.35)	0.054 (1.53)	0.83	0.30(8.39)
1982	16	0.0454(0.833)	0.0720(2.029)	0.89	0.73(21.14)

Table 4.--Annual biomass and utilization estimates by visual and herbage meter techniques, Tabor Creek, Nevada.

Year	Month Sampled	Biomass in Site 2		Biomass in Site 1		Percent Use in Site 1	
		lb/ac	kg/ha	lb/ac	kg/ha	Meter	Visual
1979	October	2055	2247	216	242	89	68
1980	September	5796	6496	1126	1262	81	72
1981	October	1251	1402	470	527	62	65
1982	August	3047[1/]	3415[1/]	2617	2933	N.A.[2/]	85

[1/] The available biomass was to be obtained from site 1 in 1982, but cattle were allowed in all sites; therefore, this value is not indicative of the potential available production.

[2/] N.A. - not applicable; all sites grazed in 1982.

Fish Population Analysis

Unlike overall aquatic and riparian habitat conditions, the beneficial effects of the first livestock exclosure are not readily apparent from fish populations. Site 3 has consistently had the greatest number and biomass of trout (Table 5; Fig. 7, Appendix 6), but stocking practices confound analysis. Catchable-size, hatchery-reared rainbow trout are planted in Tabor Creek each year, not necessarily uniformly along the length of the study reach. We attempted to identify hatchery trout in 1980 and 1982 as they were collected, but the low proportion of hatchery trout collected in 1982 (4 percent) casts some doubt on the reliability of such attempts; assuming uniform vigilance on the part of the collectors; however, it is clear that the greatest percentage of hatchery fish normally occurs in site 3 (Appendix 7). It is also obvious, however, that the small numbers of young of the year trout consistently collected were insufficient to produce the large numbers of older trout collected; therefore, in 1982 at least, the number of hatchery-reared individuals indicated is probably underestimated.

Size frequency distributions of rainbow trout were noticeably skewed toward larger individuals in an upstream direction, suggesting the presence of more favorable fishery conditions, at least with respect to larger individuals, in site 3. Several factors could lead to this condition, including: (1) heavier fish stocking in or near site 3; (2) less fishing pressure in site 3; and (3) superior habitat conditions. We cannot adequately evaluate the relative importance of those factors at this time, but some speculation is possible. Nevada Department of Wildlife creel surveys are not conclusive, but they do suggest that hatchery-reared individuals do not greatly outnumber wild individuals in anglers' creels. The average size of fish stocked into Tabor Creek since 1977 has been 8-10 in. (203-254 mm) (Pat

Table 5.--Summary of annual game fish population analysis results, Tabor Creek, Nevada.[1/]

	Study Site											
	Site 1				Site 2				Site 3			
Species/variable	1979	1980	1981	1982	1979	1980	1981	1982	1979	1980	1981	1982
Rainbow Trout												
Total catch (#)	20	27	412	158	39	17	308	192	50	68	439	278
Population estimate (#)	20	28	488	167	39	17	325	194	52	68	498	294
Mean length (in)	7.06	3.34	3.06	5.53	6.95	5.36	3.22	5.57	7.07	9.48	3.44	6.35
(mm)	179.3	84.9	77.8	140.5	176.5	136.1	81.7	141.5	179.5	240.8	87.4	161.4
Mean weight (oz)	2.60	0.99	0.30	1.18	2.50	2.32	0.33	1.29	2.75	5.32	0.45	2.11
(gm)	73.7	28.0	8.6	33.3	70.8	65.7	9.4	36.5	77.9	150.7	12.6	59.7
Estimated standing crop												
(#/ft^2)	0.002	0.003	0.060	0.019	0.006	0.002	0.050	0.026	0.007	0.009	0.067	0.039
(#/m^2)	0.026	0.034	0.644	0.205	0.068	0.026	0.540	0.278	0.076	0.095	0.721	0.403
Estimated biomass (oz/ft^2)	0.006	0.003	0.018	0.022	0.016	0.006	0.017	0.033	0.019	0.047	0.030	0.079
(gm/m^2)	1.90	0.96	5.54	6.83	4.81	1.71	5.05	10.13	5.91	14.36	9.09	24.04
Mean condition factor												
Eastern Brook Trout												
Total catch (#)	0	0	0	0	0	0	1	0	0	0	0	0
Population estimate (#)	N.A.[2/]	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Mean length (in)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	3.3	N.A.	N.A.	N.A.	N.A.	N.A.
(mm)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	85.0	N.A.	N.A.	N.A.	N.A.	N.A.
Mean weight (oz)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.2	N.A.	N.A.	N.A.	N.A.	N.A.
(gm)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	5.1	N.A.	N.A	N.A.	N.A.	N.A.
Estimated standing crop												
(#/ft^2)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	<0.001	N.A.	N.A.	N.A.	N.A.	N.A.
(#/m^2)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.002	N.A.	N.A.	N.A.	N.A.	N.A.
Estimated biomass (oz/ft^2)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	<0.001	N.A.	N.A.	N.A.	N.A.	N.A.
(gm/m^2)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.14	N.A.	N.A.	N.A.	N.A.	N.A.
Mean condition factor												

[1/] Differences between these and previous results are due to improvements in analytical technique.
[2/] N.A. - not applicable.

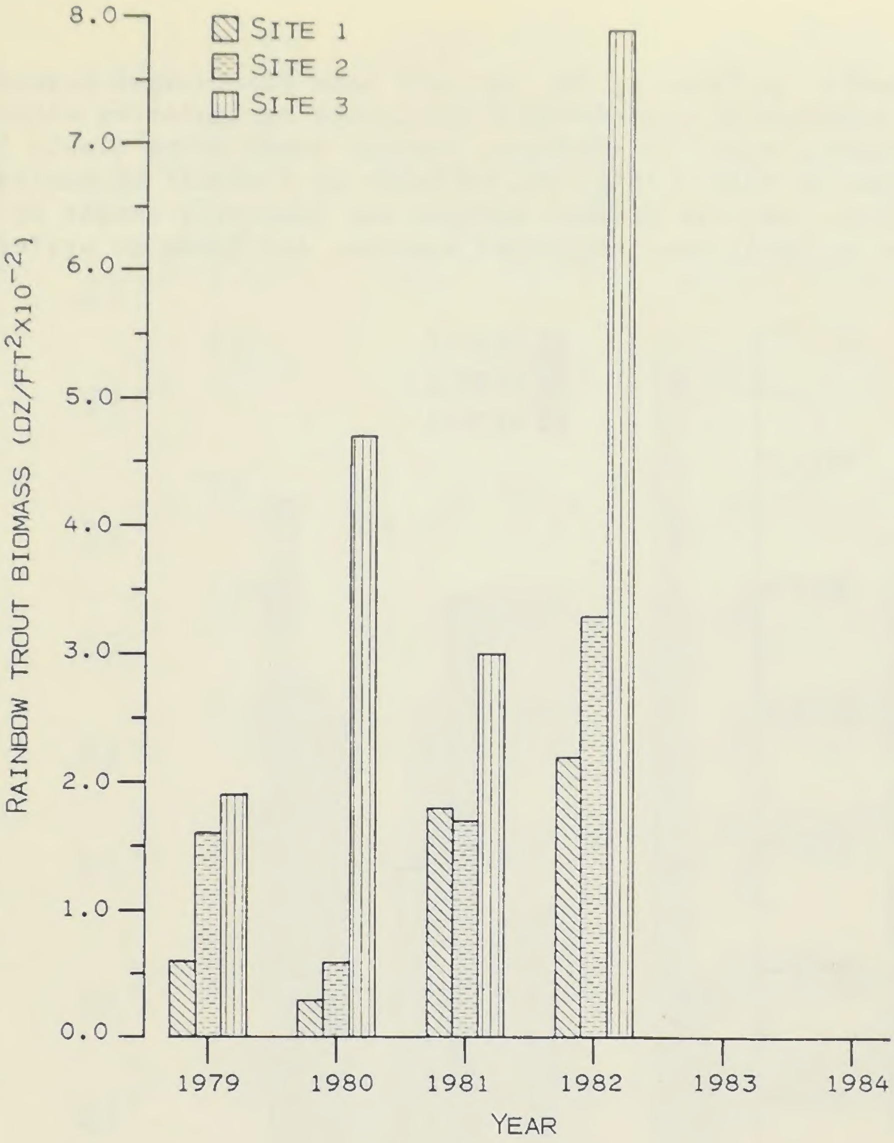


Figure 7. Fluctuations in rainbow trout biomass over time, Tabor Creek, Nevada.

Coffin, personal correspondence), so the large number of individuals smaller than 8 in. we have collected also suggests a good proportion of wild trout. Little is specifically known of the movements of wild rainbow trout in the Humboldt River Basin, but upstream movements of wild adult trout to spawning-rearing areas and subsequent return could account for large numbers of wild fish despite small numbers of young of the year. In addition, if stocking occurred above and below the study area, downstream movements of planted fish might well be expected to result in decreasing numbers of hatchery trout along a downstream gradient.

The above arguments possibly account for much of the observed rainbow trout spatial and size-frequency distributions, but presence of superior habitat conditions and differential angling pressure must also be considered. Geomorphic/aquatic and riparian analysis results do not indicate markedly superior conditions, but critical components may be masked. For example, large numbers of large trout were collected in site 3 under heavy vegetation overhang, principally of willow. This may have been insufficient in quantity to show up clearly in Table 1, but may well have discouraged casual anglers; we, in fact, experienced considerable difficulty manipulating electrofishers and nets in these areas. In addition, sculpin study crops (Table 6) were typically higher in site 3 (Fig. 8), probably as a result of habitat preferences since they are neither stocked nor regularly caught by anglers. Piute sculpin, probably the indigenous species, are known to prefer clear,

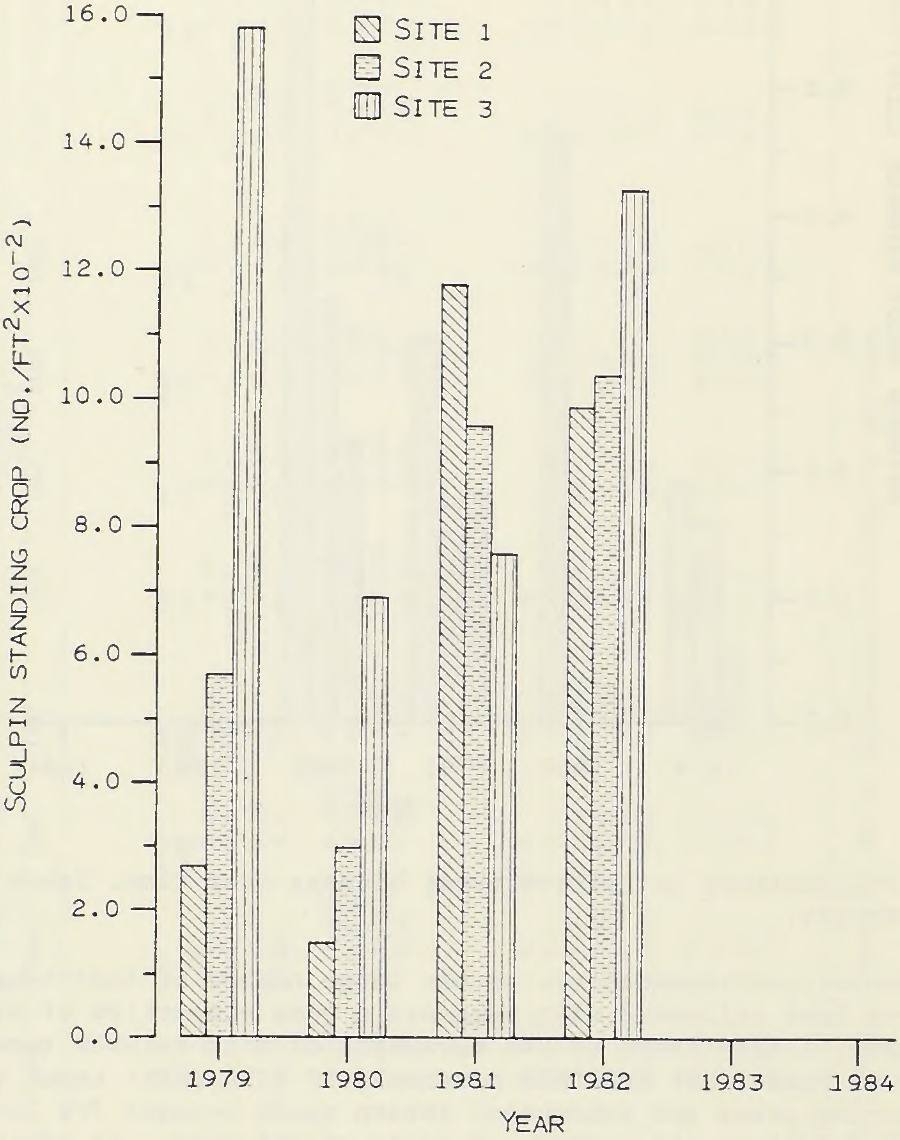


Figure 8. Changes in sculpin standing crop over time, Tabor Creek, Nevada.

cold water and to occur over rubble bottoms (Jones 1972; Simpson and Wallace 1978) as do trout, and researches on other sculpins imply that they have substrate and food requirements similar to those of trout (Bailey 1952; Dineen 1951; Koster 1937), suggesting that habitat conditions in site 3 are most favorable. The consistent absence of dace and sucker from site 3 may be further indication of superior trout habitat conditions, though sucker were absent from all sites in 1982.

Table 6.--Summary of annual non-game fish population results, Tabor Creek, Nevada.[1]

Species/variable	Study Site											
	Site 1				Site 2				Site 3			
	1979	1980	1981	1982	1979	1980	1981	1982	1979	1980	1981	1982
Sculpin												
Total catch (#)	212	124	622	689	305	156	551	679	921	374	444	815
Population estimate (#)	227	134	966	871	352	208	624	785	1166	528	565	1049
Mean weight (oz)	0.17	0.22	0.10	N.D.[3]	0.16	0.17	0.10	N.D.	0.08	0.16	0.13	N.D.
(gm)	4.9	6.2	2.8	N.D.	4.5	4.9	2.9	N.D.	2.2	4.4	3.7	N.D.
Estimated standing crop												
(#/ft^2)	0.027	0.015	0.118	0.099	0.057	0.030	0.096	0.104	0.158	0.069	0.076	0.133
(#/m^2)	0.293	0.165	1.274	1.070	0.613	0.312	1.037	1.124	1.701	0.740	0.817	1.437
Estimated biomass (oz/ft^2)	0.005	0.003	0.119	N.D.	0.009	0.005	0.010	N.D.	0.012	0.011	0.010	N.D.
(gm/m^2)	1.44	1.02	3.62	N.D.	2.77	1.58	3.00	N.D.	3.67	3.28	3.03	N.D.
Dace												
Total catch (#)	2	0	4	14	0	1	16	14	1	0	0	0
Population estimate (#)	2	N.A.	4	20	N.A.	N.A.	18	14	N.A.	N.A.	N.A.	N.A.
Mean weight (oz)	0.11	N.A.	0.17	N.D.	N.A.	2.00	0.20	N.D.	0.21	N.A.	N.A.	N.A.
(gm)	3.0	N.A.	4.7	N.D.	N.A.	56.7	5.6	N.D.	6.0	N.A.	N.A.	N.A.
Estimated standing crop[4]												
(#/ft^2)	<0.001	N.A.	<0.001	0.002	N.A.	<0.001	0.003	0.002	<0.001	N.A.	N.A.	N.A.
(#/m^2)	0.003	N.A.	0.005	0.025	N.A.	0.002	0.030	0.020	0.001	N.A.	N.A.	N.A.
Estimated biomass[4] (oz/ft^2)	<0.001	N.A.	<0.001	N.D.	N.A.	<0.001	<0.001	N.D.	<0.001	N.A.	N.A.	N.A.
(gm/m^2)	0.01	N.A.	0.02	N.D.	N.A.	0.09	0.17	N.D.	0.01	N.A.	N.A.	N.A.
Sucker												
Total catch (#)	0	1	32	30	14	9	46	49	0	0	0	4
Population estimate	N.A.	N.A.	38	35	14	9	46	50	N.A.	N.A.	N.A.	4
Mean weight (oz)	N.A.	1.29	1.03	N.D.	1.08	1.08	1.19	N.D.	N.A.	N.A.	N.A.	N.D.
(gm)	N.A.	36.5	29.3	N.D.	30.8	30.6	33.6	N.D.	N.A.	N.A.	N.A.	N.D.
Estimated standing crop[4]												
(#/ft^2)	N.A.	<0.001	0.005	0.004	0.002	0.001	0.007	0.007	N.A.	N.A.	N.A.	<0.001
(#/m^2)	N.A.	0.001	0.050	0.043	0.024	0.014	0.076	0.072	N.A.	N.A.	N.A.	<0.005
Estimated biomass[4] (oz/m^2)	N.A.	<0.001	0.005	N.D.	0.002	0.001	0.008	N.D.	N.A.	N.A.	N.A.	N.D.
(gm/m^2)	N.A.	0.04	1.47	N.D.	0.75	0.42	2.57	N.D.	N.A.	N.A.	N.A.	N.D.

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[1] Differences between these and previous results are due to improvements in analytical technique.
[2] N.A. - not applicable.
[3] N.D. - no data; non-game fish were counted only in 1982.
[4] Based on total catch when population estimate is unavailable.

Eastern brook trout, one small individual, were collected only in 1981, and must be considered an insignificant component of the Tabor Creek fish community.

Hydraulic and Channel Geometry Analysis

Stream channel structural characteristics are expected to respond more slowly to protection from grazing than characteristics based solely upon vegetative proliferation. Despite this consideration, the stream channel in site 2 was seen to be narrower and deeper in cross section in 1979 (Table 7; Appendix 6), 11 years after construction of the exclosure and just 3 years after the exclosure was completely closed to livestock use. Other hydraulic characteristics were noticeably different within the exclosure, most noticeable slope and roughness, and site 3 was seen to be somewhat different than site 1. This is not surprising since site 3 is situated some distance upstream and not continuous with site 2; however, site 3 is more similar to site 1 than site 2 with respect to most characters.

Table 7.--Hydraulic and channel geometry characteristics, Tabor Creek, Nevada (8/13/79).

	Study Site		
Variable[1/]	Site 1	Site 2	Site 3
Sample size	7	7	9
Average velocity (ft/sec)	1.24	1.16	1.23
Average flow (ft^3/sec)	5.51	5.36	4.34
Average wetted roughness	0.005	0.11	0.07
Average slope (pct)	0.085	2.49	1.60
Average width (ft)	11.80	9.96	11.18
Average depth (ft)	0.427	0.556	0.407
Average cross-sectional area (ft^2)	4.66	4.79	4.09

[1/] Averages of wetted values recorded for each transect (except sample size).

Of particular interest was the increased channel roughness (Manning's n)[3/] in site 2. This resulted from the decrease in width and increase in depth (note that area is little different between sites 1 and 2) which decreased the wetted perimeter relative to cross-sectional area. Concurrent decrease in velocity and the greater slope yielded an increased roughness coefficient.

Hydrologic surveys were not conducted in 1979.

[3/] Manning's n = $\frac{R^{2/3}S^{\frac{1}{2}}}{v}$, where: R = A/(2d + w); A = area; d = depth; w = width; s = slope; and v = velocity.

Water Quality Analysis

Water quality sampling was performed at three different dates and at three different dates and at three separate locations on Tabor Creek in both 1979 and 1980. The results of these surveys are presented in Tables 8 and 9.

Tabor Creek appeared to contain clear, fertile, moderately alkaline water which can get quite warm in the summer months. Most of the water quality characteristics were observed to exhibit expected seasonal and spatial fluctuations and only a few approached levels that could be sources of stress to game fish populations, and those only during certain periods. One of these, temperature, was observed to be as high as 64° F (18° C). This is above the 55° F (13° C) rainbow trout optimum reported by McKee and Wolf (1971), but within tolerable limits. Water temperatures were higher in 1980 than 1979.

Dissolved solids, bicarbonates, carbonates, calcium, chlorides, and pH were at their lowest levels when stream flows were high and concentrate as flows diminish; however, some did drop slightly after a mid-season high, possibly as a result of decreased evapotranspiration. Concentrations of all of these substances were within limits tolerable to trout. Bicarbonate and chloride levels slightly exceeded the levels reported by McKee and Wolf (1971) to be found in 95 percent of all water in the United States that support a good, mixed fish fauna (180 mg/l and 170 mg/l respectively).

One striking feature of Tabor Creek was its high fertility. Orthophosphate data is available only from 1980, but the high average concentration observed (0.43 mg/l) is well above the 0.01 mg/l level that is reported by McKee and Wolf (1971) to be conclusive to high biotic production. It is also well above the range of 0.01 to 0.1 mg/l normally encountered in U.S. rivers, and, if fertilizers or other sources of pollution are not the source, may indicate phosphate deposits in the Tabor Creek watershed. Nitrate concentrations were also sufficient to encourage aquatic plant growth. The existence of which may be indicated by the mid-summer declines in both phosphate and nitrate concentrations. Coliform counts, also components of fertility, were highest during the grazing season as expected, but the dramatic differences between 1979 and 1980 are puzzling.

Table 8.--Water quality characteristics of Tabor Creek, Nevada. Sampling was performed on three dates: (1) 8 May; (2) 24 July; (3) 18 September, 1979. Data provided by USDI-BLM, Elko District Office, Elko, Nevada, and averaged by the authors.

Characteristic	Below Study Area				Study Area				Above Study Area				Averages			
	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.
Physical																
Temperature (°C)	5	18	15	12.7	5	14	13	10.7	5	13.5	12	10.7	5.0	15.2	13.3	11.2
Turbidity (JTU)	19	0.0	0	6.6	13	0	0.9	4.6	15	0	6.3	7.1	15.7	0.3	2.4	6.1
Bacteriological																
Fecal Coliform (no./100 ml)	0	0	200	67	0	0	160	53	0	100	100	67	0	33	153	62
Total coloform (no./100 ml)	90	0	200	97	436	20	375	277	100	300	130	177	209	107	235	183
Chemical																
pH	7.70	8.4	8.80	8.30	7.65	8.4	8.55	8.20	7.5	8.2	8.45	8.05	7.62	8.33	8.60	8.18
Dissolved solids (mg/l)	138	150	192	160.0	139	160	170	156.3	120	160	115	131.7	132.3	156.7	159.0	149.3
Bicarbonate (mg/l)	71	165	145	127.0	69	117	163	116.3	68	150	182	133.3	69.3	144.0	163.3	125.6
Carbonate (mg/l)	0	10	42	17.3	0	60	26	31.3	0	0	4	1.3	0	26.0	24.0	16.7
Orthophosphate (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate-N (mg/l)	0.66	0.05	0.22	0.31	0.51	0.12	0.36	0.38	0.67	0.16	0.44	0.42	0.61	0.11	0.34	0.35
Arsenic (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium (mg/l)	13	40	36	29.7	12	37	38	29.0	11.5	37	36.5	28.3	12.2	38.0	36.8	29.0
Chloride (mg/l)	70	184	164	139.3	60	175	170	135.0	65	192	169	142.0	65.0	183.7	167.7	138.8
Copper (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manganese (mg/l)	-	-	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-
Potassium (mg/l)	1.8	0.85	0.87	1.17	1.9	0.87	0.90	1.22	2.0	0.85	0.84	1.28	1.90	0.86	0.87	1.21
Sodium (mg/l)	2.1	-	1.6	-	1.8	-	1.9	-	2.1	0	1.9	-	2.0	-	1.80	-
Sulfate (mg/l)	18	11	11	13.3	16	12	12	13.3	17	11	10	12.7	17.0	11.3	11.0	13.1
Zinc (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 9.--Water quality characteristics of Tabor Creek, Nevada. Sampling was performed on three dates: (1) 1 May; (2) 15 July; (3) 24 September, 1980. Data provided by USDI-BLM, Elko District Office, Elko, Nevada, and averaged by the authors.

	Below Study Area				Study Area				Above Study Area				Averages			
Characteristic	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.
Physical																
Temperature (°C)	6	17	17	13.3	5	17	17	13.0	5	17	16	12.7	5.3	17.0	16.7	13.0
Turbidity (NTU)	98	0.4	1.2	36.8	67	0.6	1.8	23.1	52	0.5	1.3	17.9	72.3	0.5	1.0	24.8
Bacteriological																
Fecal Coliform (no./100 ml)	5	70	80	52	16	150	60	75	8	150	40	66	10	123	60	64
Total coloform (no./100 ml)	800	1900	1500	1400	200	2600	80	960	400	4700	80	1727	467	3067	553	1362
Chemical																
pH	6.8	8.3	8.0	7.70	6.6	8.0	8.0	7.53	6.3	7.8	6.9	7.33	6.57	8.03	7.97	7.52
Dissolved solids (mg/l)	105	175	175	151.7	99	175	180	151.3	98	175	180	151.0	100.7	175.0	178.0	141.3
Bicarbonate (mg/l)	64	128	150	114.0	62	126	164	117.3	64	150	166	126.7	63.3	134.7	160.0	119.3
Carbonate (mg/l)	0	24	20	14.7	0	32	16	16.0	0	0	20	6.7	0.0	18.7	18.7	12.4
Orthophosphate (mg/l)	0.34	0.2	-	-	0.33	0.3	-	-	0.61	0.3	0.1	0.3	0.43	0.27	-	-
Nitrate-N (mg/l)	0.4	-	0.2	-	0.3	-	0.3	-	0.2	-	0.2	-	0.30	-	0.23	-
Arsenic (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium (mg/l)	7	50	29	28.7	7	50	32	29.7	6	54	32	30.7	6.7	51.3	31.0	29.7
Chloride (mg/l)	-	2	1	-	-	2	2	-	1	1	1	1.0	-	1.7	1.3	-
Copper (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manganese (mg/l)	0.04	-	0.05	-	0.04	-	0.05	-	0.03	-	0.05	-	0.04	-	0.05	-
Potassium (mg/l)	0.5	0.2	0.1	0.27	0.5	-	0.2	-	0.5	-	0.2	-	0.50	-	0.17	-
Sodium (mg/l)	4	7.5	8	6.5	4	5.9	8	6.0	3	7.2	6	5.4	3.7	6.9	7.3	6.0
Sulfate (mg/l)	9	14	8	10.3	12	12	9	11.0	11	13	8	10.7	10.7	13.0	8.3	10.7
Zinc (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CONCLUSIONS

Four years of data collection are insufficient to completely identify trends that may be developing in Tabor Creek habitat conditions, though some extrapolation from differences between protected and unprotected areas is justifiable. It should be borne in mind, however, that streams are innately dynamic entities, especially in such an unpredictable geoclimatic region, and it is common for habitat conditions to fluctuate from one year to the next. It is also true that a certain amount of observer bias is inherent in any measurements that attempt to evaluate such habitat conditions, so it is necessary to exercise caution when analyzing data early in a time trend study; we must make the assumption that observed changes are real, but it will take accumulation of additional years' data to dilute the effects of observer biases.

Most habitat conditions were found to be superior within the first exclosure (site 2), presumably as a result of the rest from grazing. It appears that the continuous grazing system in use on Tabor Creek is preventing the riparian system from contributing fully to the stream and its fishery, though the better fish population in the upstream control site despite somewhat poorer conditions add a confounding factor. Possible reasons for this apparent anomally include fish stocking, the unknown influence of recreational angling; high sculpin standing crops preclude ruling out the possibility of superior conditions with respect to some currently, unevaluated habitat component (e.g. in situ or allocthonous food supply). Preliminary analysis suggests that rest-rotation grazing at the high forage use levels intended will have some effect on the improved riparian and stream habitat within the first exclosure, but it is too early to speculate on the magnitude of such impacts.

Construction of the second exclosure, which had been scheduled for the 1982 grazing season, should instead be completed by the 1983 season. Protection of site 1, for which we have abundant data regarding grazed conditions, will allow observation of the rehabilitation process from the beginning and will eliminate the bias of not having pre-treatment data. As the BLM continues to more fully develop multiple-use potential on public domain lands, it will become increasingly necessary to devise grazing systems that will allow livestock production and protection of valuable fishery habitat.

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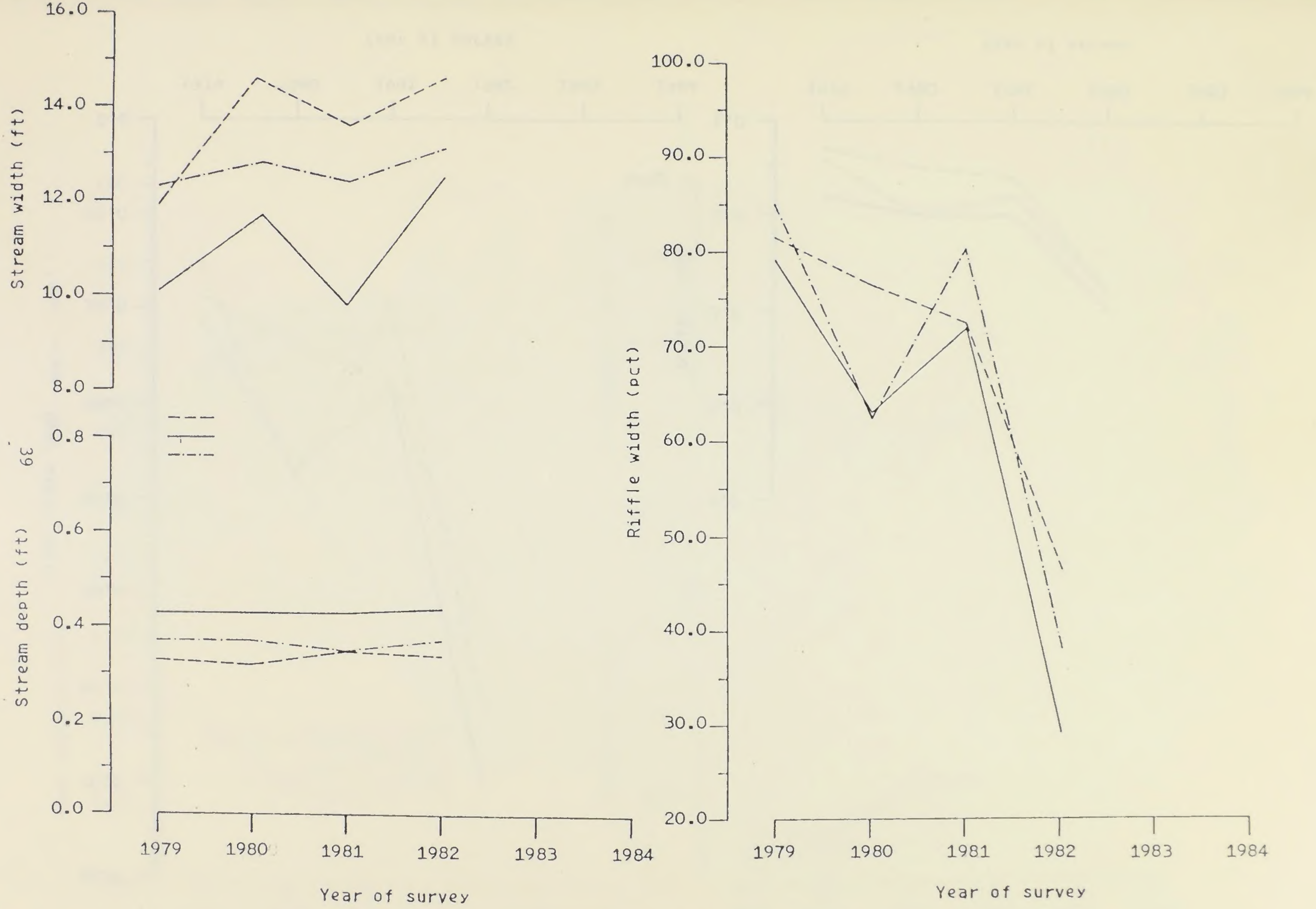
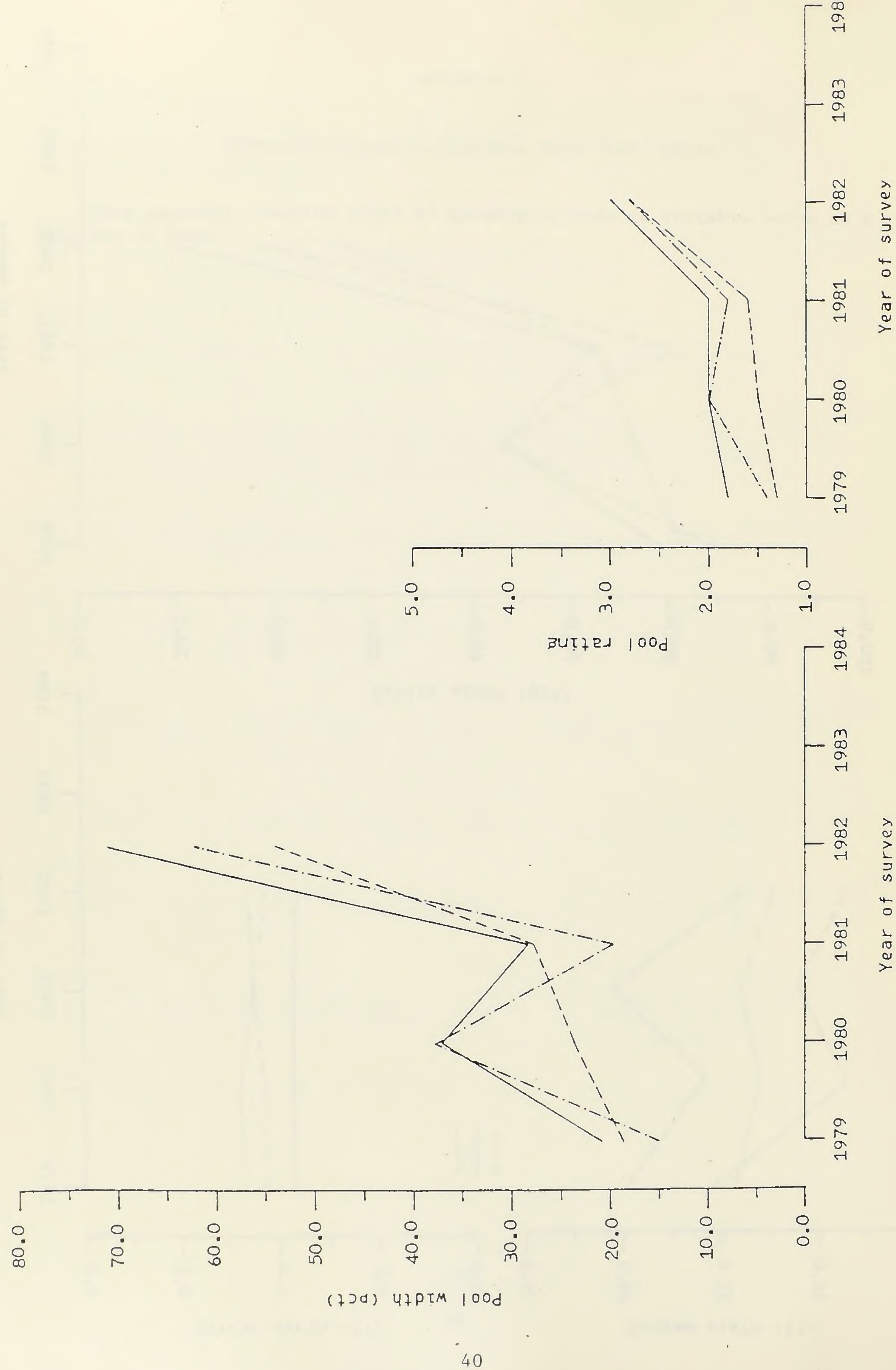
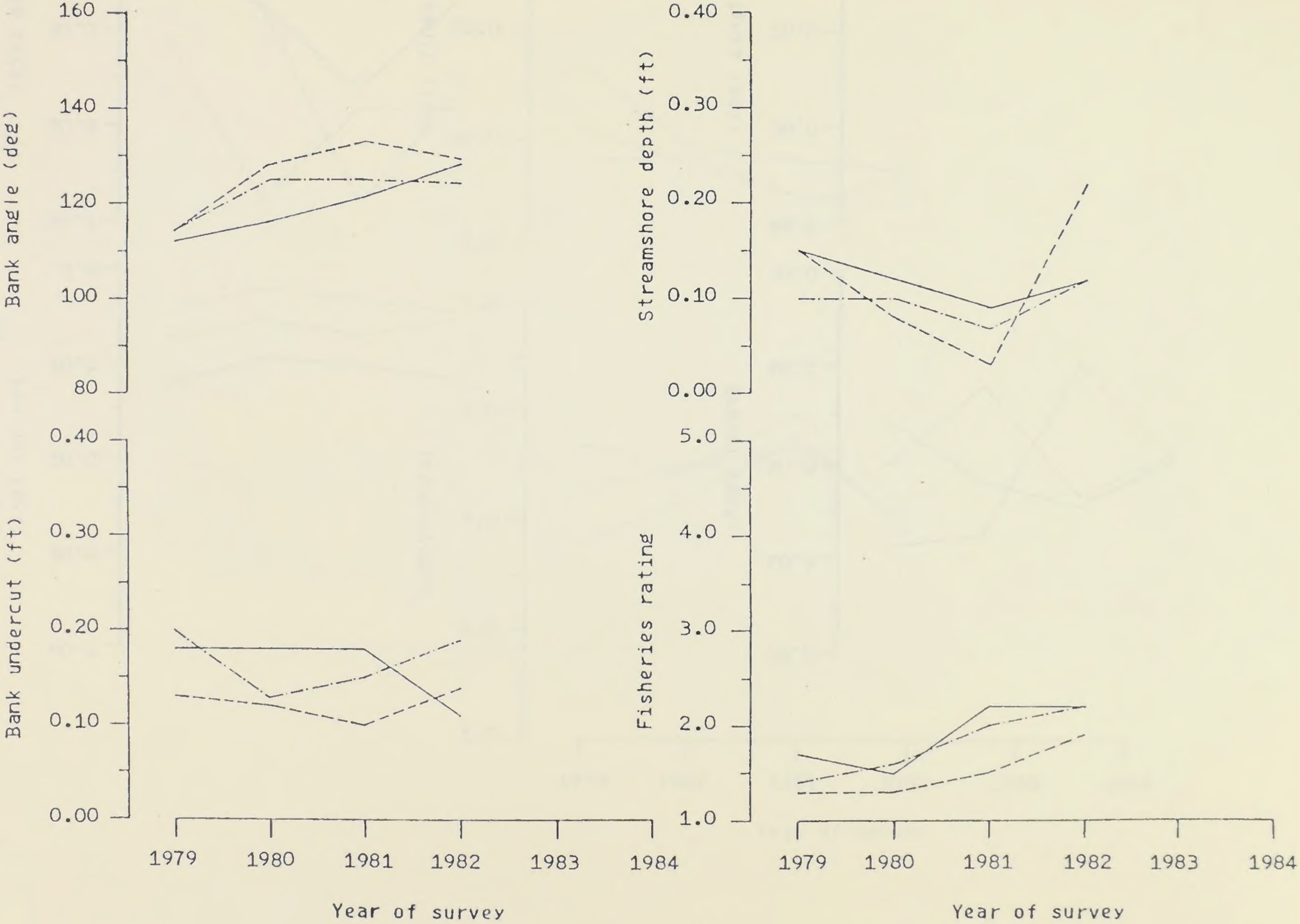
APPENDIX 1

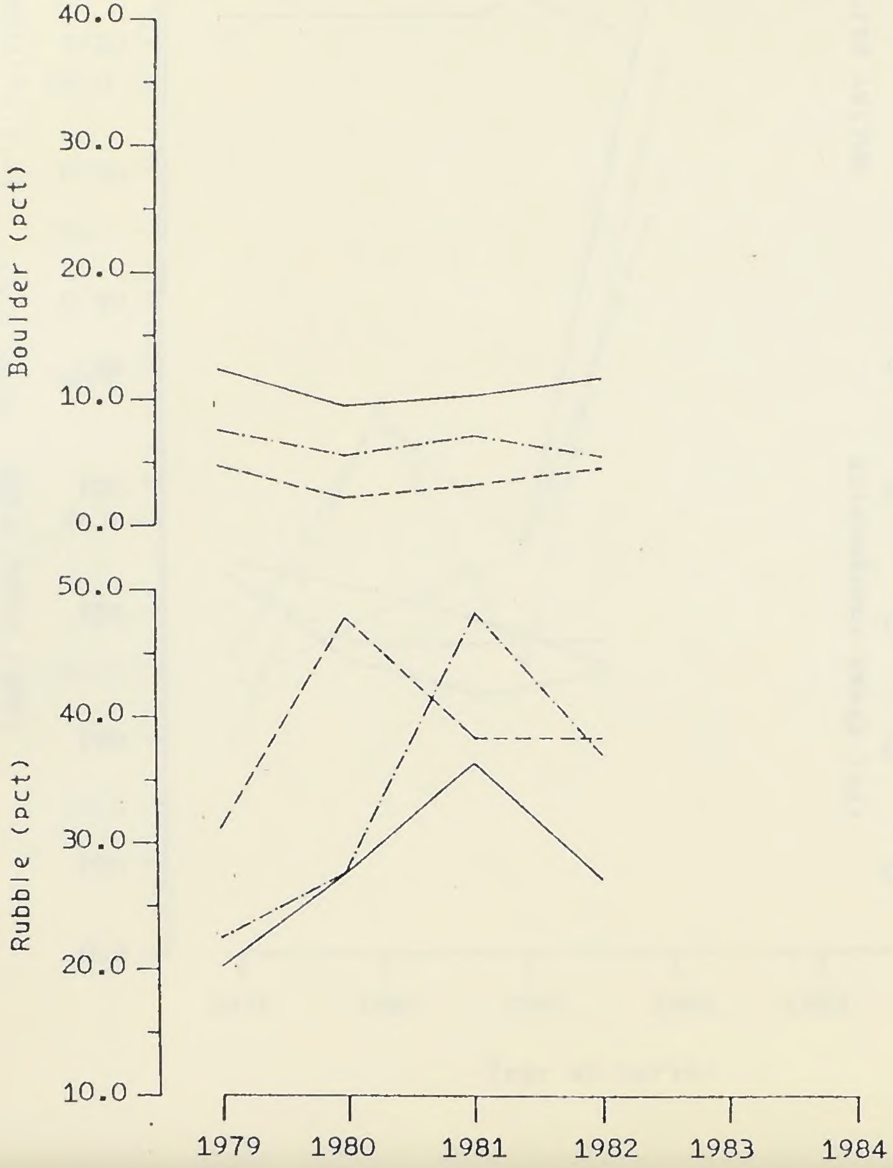
Geomorphic/Aquatic Analysis Time Trend Plots

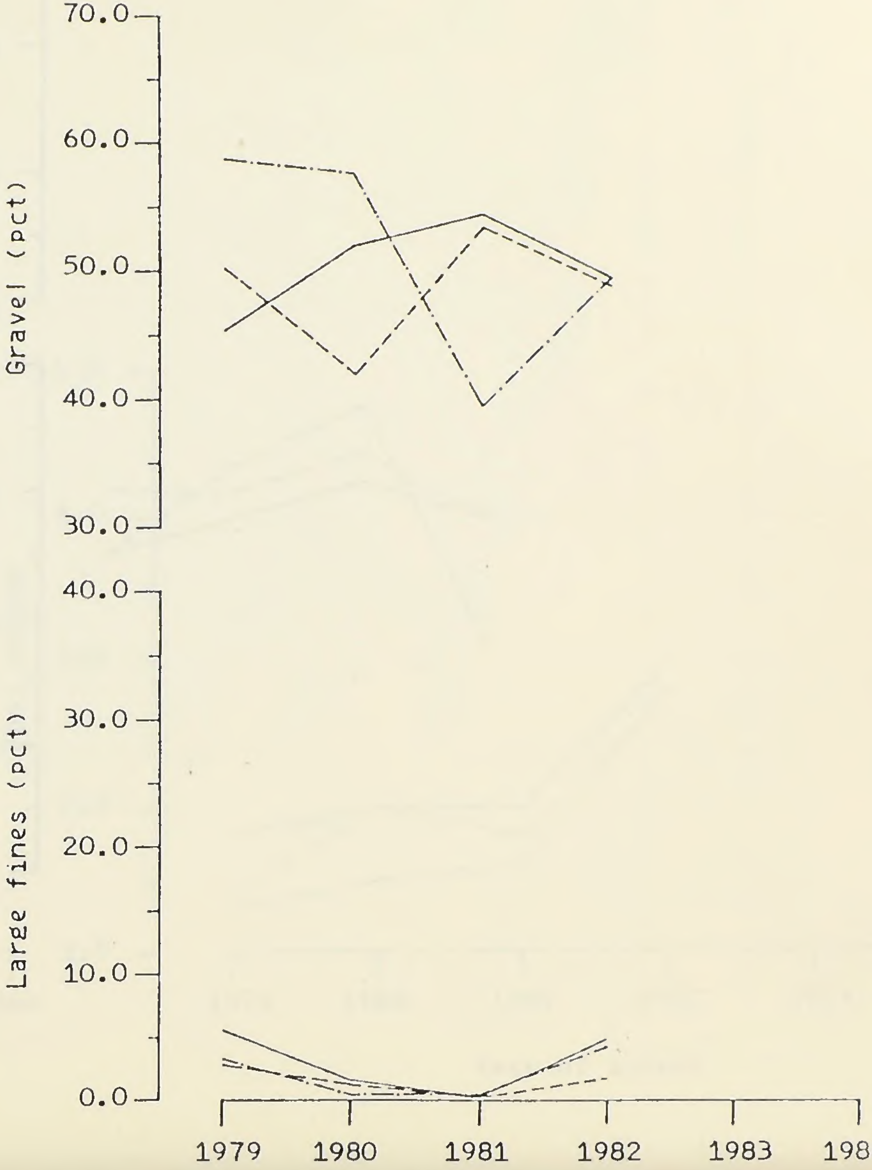
This appendix contains plots of geomorphic/aquatic variable means as a function of time.

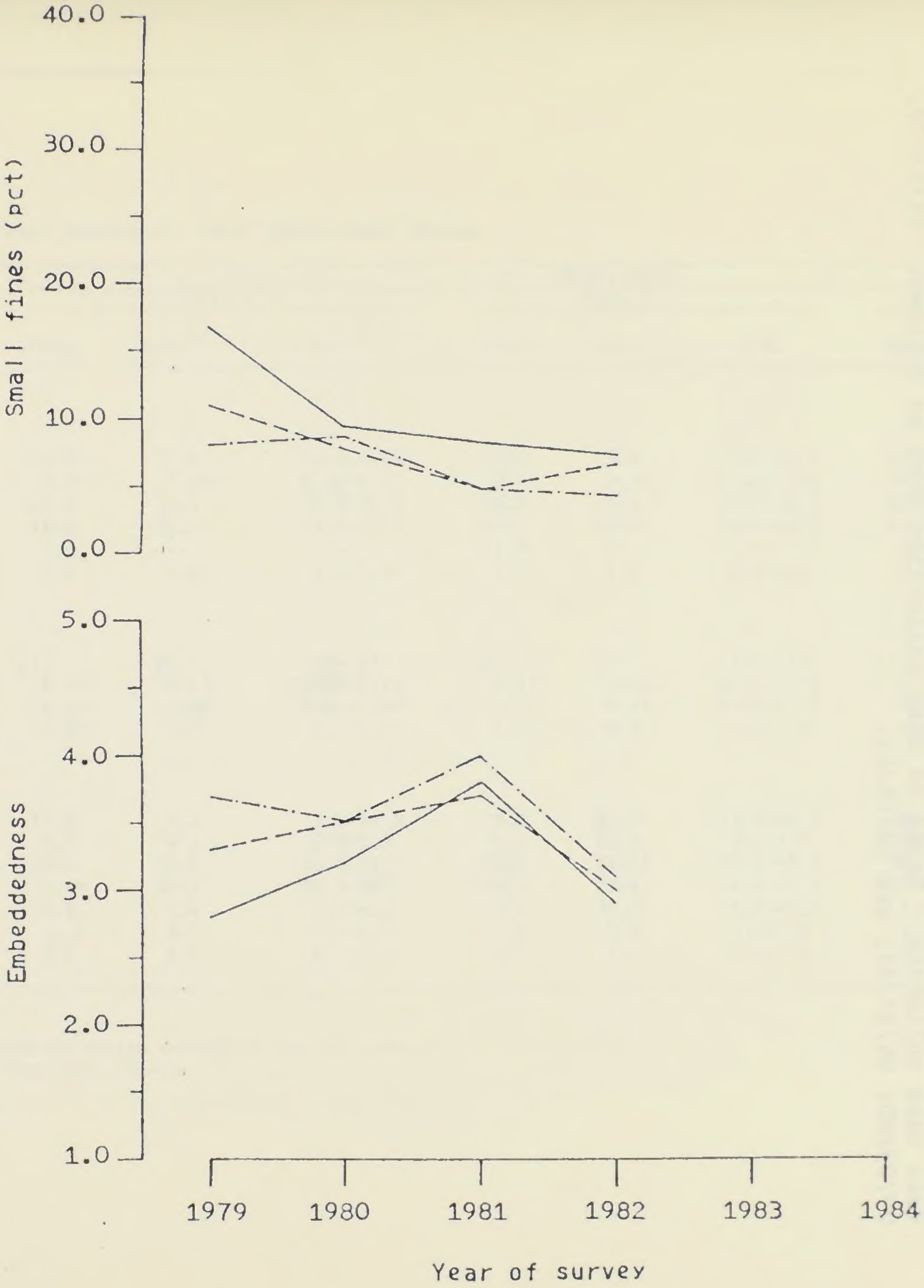

16.0
14.0
12.0
10.0
8.0
Stream width (ft)
0.8
0.6
0.4
0.2
0.0
Stream depth (ft)
1979
1980
1981
1982
1983
1984
Year of survey
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
Riffle width (pct)
1979
1980
1981
1982
1983
1984
Year of survey


Pool width (pct)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
1979
1980
1981
1982
1983
1984
Year of survey
Pool rating
1.0
2.0
3.0
4.0
5.0
1979
1980
1981
1982
1983
1984
Year of survey


Bank angle (deg)
160
140
120
100
80
Streamshore depth (ft)
0.40
0.30
0.20
0.10
0.00
Bank undercut (ft)
0.40
0.30
0.20
0.10
0.00
Fisheries rating
5.0
4.0
3.0
2.0
1.0
1979
1980
1981
1982
1983
1984
Year of survey
1979
1980
1981
1982
1983
1984
Year of survey


Boulder (pct)
40.0
30.0
20.0
10.0
0.0
Rubble (pct)
50.0
40.0
30.0
20.0
10.0
1979
1980
1981
1982
1983
1984


Gravel (pct)
70.0
60.0
50.0
40.0
30.0
Large fines (pct)
40.0
30.0
20.0
10.0
0.0
1979
1980
1981
1982
1983
1984


40.0
30.0
20.0
10.0
0.0
Small fines (pct)
5.0
4.0
3.0
2.0
1.0
Embeddedness
1979
1980
1981
1982
1983
1984
Year of survey

APPENDIX 2

Annual Geomorphic/Aquatic Analysis Results

This appendix contains tables of geomorphic/aquatic analysis variable means, standard deviations, and 95 percent confidence intervals for each year data were collected. Dates of data collection were as follows: 08/11/79; 09/03/80; 06/27/81; and 08/06/82.

Table A-1.--Geomorphic/aquatic analysis results for 1979, Tabor Creek, Nevada.

	Study Site								
	Site 1			Site 2			Site 3		
Variable	Mean	S.D.[1/]	C.I.[2/]	Mean	S.D.	C.I.	Mean	S.D.	C.I.
Water column									
Stream width (feet)	13.9*	4.8	12.9-14.9	10.2	3.6	9.2-11.2	12.4*	3.3	11.4-13.4
Stream depth (feet)	0.33*	0.100	0.29-0.37	0.44	0.23	0.40-0.48	0.36	0.11	0.32-0.40
Riffle width (percent)	81.4	20.2	75.9-86.9	78.7	24.6	73.2-84.2	85.5	19.5	80.0-91.0
Pool width (percent)	18.6	20.2	13.1-24.1	21.3	24.6	15.8-26.8	14.5	19.5	9.0-20.0
Pool feature	1.0	--	--	1.6	--	--	1.0	--	--
Pool rating	1.3	0.8	1.0-1.6	1.8	1.2	1.5-2.1	1.4	0.9	1.1-1.8
Streambanks									
Bank angle (degrees)	114	29	106-122	110	35	102-118	111	28	103-119
Bank undercut (feet)	0.13	0.15	0.068-0.18	0.17	0.28	0.11-0.23	0.20	0.23	0.15-0.26
Bank depth (feet)	0.05	0.09	0.01-0.09	0.07	0.21	0.03-0.11	0.08	0.16	0.04-0.12
Fisheries rating	1.3*	0.6	1.1-1.5	1.7	0.9	1.6-1.9	1.4*	0.5	1.2-1.6
Streambottom									
Fines <0.03 in. (percent)	11.0	9.7	7.6-14.5	16.8	17.5	13.3-20.3	8.0*	12.5	4.5-11.5
Fines >0.03 in. (percent)	2.9	6.3	0.6-5.2	5.5	10.6	3.2-7.8	3.0	9.4	0.8-5.4
Gravel (percent)	50.2	21.4	43.4-57.0	45.3	29.6*	38.5-52.2	58.9*	28.2	52.1-65.8
Rubble (percent)	31.1*	20.9	25.7-36.5	20.1	23.1	14.6-25.5	22.6	20.0	17.1-28.1
Boulder (percent)	4.8	5.4	0.5-9.0	12.3	24.9	8.0-16.6	7.6	13.6	3.4-11.9
Substrate embeddedness	3.3*	0.7	3.1-3.5	2.8	0.9	2.6-3.0	3.7*	0.9	3.5-3.9
Instream vegetation cover (feet)	0.2	1.0	0 -0.5	0.7	1.3	0.4-1.0	0.3	0.8	0.07-0.6

[1/] SD - standard deviation.

[2/] CI - 95% confidence interval; based on pooled variances for all sites.

*Significantly different (P<0.05) from site 2 mean.

Table A-2--Geomorphic/aquatic analysis results for 1980, Tabor Creek, Nevada

	Study Site								
	Site 1			Site 2			Site 3		
Variable	Mean	SD[1]	CI[2]	Mean	SD	CI	Mean	SD	CI
Water column									
Stream width (feet)	14.6*	4.1	13.7-15.6	11.7	3.5	10.8-12.6	12.8	3.5	11.9-13.8
Stream depth (feet)	0.32	0.12	0.29-0.36	0.43	0.18	0.39-0.47	0.37	0.15	0.34-0.41
Riffle width (percent)	76.5*	19.8	70.4-82.7	63.0	26.4	56.9-69.2	62.3	25.3	56.1-68.4
Pool width (percent)	23.5*	19.8	17.3-29.6	37.0	26.4	30.8-43.1	37.7	25.3	31.6-43.9
Pool feature	1.0	--	--	1.3	--	--	1.0	--	--
Pool rating	1.5	1.0	1.1-1.8	2.0	1.2	1.6-2.3	2.0	1.5	1.6-2.3
Streambanks									
Bank angle (degrees)	128	33	119-137	116	39	107-125	125	33	116-134
Bank undercut (feet)	0.12	0.20	0.06-0.17	0.18	0.24	0.13-0.24	0.13	0.20	0.08-0.19
Bank depth (feet)	0.08	0.12	0.04-0.11	0.12	0.16	0.08-0.16	0.10	0.13	0.06-0.14
Fisheries rating	1.3	0.5	1.1-1.4	1.5	0.6	1.4-1.7	1.6	0.8	1.4-1.8
Streambottom									
Fines <0.03 in. (percent)	7.8	9.5	4.6-11.0	9.5	12.1	6.3-12.7	8.6	15.1	5.4-11.7
Fines >0.03 in. (percent)	1.1	3.0	0.3-2.0	1.5	4.6	0.6-2.4	0.4	2.1	0.0-1.2
Gravel (percent)	41.0	22.7	35.3-46.7	52.0	22.1	46.3-57.7	57.7	21.7	52.1-63.4
Rubble (percent)	47.9*	22.6	43.1-52.7	27.7	16.7	22.8-32.5	27.9	16.6	23.0-32.7
Boulder (percent)	2.2*	4.9	0.0-4.4	9.4	11.5	7.1-11.6	5.5	8.8	3.2-7.7
Substrate embeddedness	3.5	0.6	3.2-3.7	3.2	0.9	3.0-3.4	3.5	0.9	3.3-3.7
Instream vegetation cover (feet)	0.4	1.2	0.1-0.6	0.7	1.1	0.4-0.9	0.2*	0.5	0.1-0.4

[1] SD - standard deviation.
[2] CI - 95% confidence interval; based on pooled variances for all sites.
*Significantly different ($P<0.05$) from site 2 mean.

Table A-3--Geomorphic/aquatic analysis results for 1981, Tabor Creek, Nevada.

	Study Site								
	Site 1			Site 2			Site 3		
Variable	Mean	SD[1]	CI[2]	Mean	SD	CI	Mean	SD	CI
Water column									
Stream width (feet)	13.6*	3.7	12.7-14.5	10.8	3.2	9.9-11.7	12.4	3.6	11.5-13.3
Stream depth (feet)[3]									
Riffle width (percent)[3]	72.3	24.5	65.9-78.7	71.9	24.8	65.5-78.3	80.3	20.5	73.9-86.7
Pool width (percent)	27.7	24.5	21.3-34.2	28.2	24.8	21.8-34.6	19.7	20.5	13.3-26.1
Pool feature	3.7	--	--	4.7	--	--	3.8	--	--
Pool rating	1.6	1.1	1.3-1.9	2.0	1.4	1.7-2.4	1.8	1.2	1.4-2.1
Canopy cover (degrees)	123	41	112-133	131	33	120-142	119	49	108-129
Streambanks									
Bank angle (degrees)	133	30	125-142	121	34	113-130	125	32	116-133
Bank undercut (feet)	0.10	0.14	0.03-0.16	0.18	0.31	0.12-0.24	0.15	0.23	0.09-0.21
Bank depth (feet)	0.03	0.08	0.0-0.06	0.09	0.16	0.06-0.13	0.07	0.14	0.04-0.10
Fisheries rating	1.5*	0.6	1.3-1.7	2.2	0.82	2.0-2.4	2.0	0.8	1.8-2.2
Streambottom									
Fines <0.03 in. (percent)	4.8	9.3	1.9-7.6	8.1	14.7	5.2-11.1	4.9	9.5	2.0-7.8
Fines >0.03 in (percent)	0.2	1.3	0.0-0.6	0.2	1.6	0.0-0.6	0.4	1.9	0.0-0.8
Gravel (percent)	53.4	24.6	47.3-59.6	43.7	24.4	37.6-49.8	39.6*	22.7	33.4-45.7
Rubble (percent)	38.2	22.5	32.6-43.7	36.3	20.7	30.7-41.9	48.2*	22.0	42.6-53.7
Boulder (percent)	3.2*	5.8	0.5-12.8	10.1	13.1	7.4-12.8	7.0	11.4	4.3-9.7
Substrate embeddedness	3.7	0.8	3.5-3.9	3.7	0.9	3.4-3.9	4.0	0.9	3.8-4.3
Instream vegetation cover (feet)	0.3	0.7	0.2-0.5	0.1	0.3	0.0-0.3	0.5*	1.0	0.3-0.6

[1] SD - standard deviation.

[2] CI - 95% confidence interval; based on pooled variances for all sites.

[3] Standard deviations and confidence intervals for these two variables in 1980 are very close approximations, but difficulties with computer analysis required separate calculations.

*Significantly different (<0.05) from site 2 mean.

Table A-4--Geomorphic/aquatic analysis results for 1982, Tabor Creek, Nevada.

	Study Site								
	Site 1			Site 2			Site 3		
Variable	Mean	SD[1/]	CI[2/]	Mean	SD	CI	Mean	SD	CI
Water column									
Stream width (feet)	14.6	4.4	13.5-15.7	12.5	4.6	11.4-13.6	13.1	3.6	12.0-14.2
Stream depth (feet)	0.34*	0.12	0.30-0.37	0.44	0.17	0.40-0.47	0.37	0.13	0.34-0.41
Riffle width (percent)	46.4*	26.6	39.4-53.4	29.1	27.2	22.1-36.1	38.1	28.2	31.0-45.1
Pool width (percent)	53.6*	26.6	46.6-60.6	70.9	27.2	63.9-77.9	61.9	28.2	54.9-69.0
Pool feature	4.6	--	--	6.5	--	--	4.6	--	--
Pool rating	2.8	1.2	2.5-3.1	3.0	1.3	2.7-3.3	2.8	1.3	2.4-3.1
Canopy cover (degrees)	110	51	98-121	125	31	114-137	95*	51	83-107
Light intensity (percent)									
Streambanks									
Bank angle (degrees)	129	37	120-137	128	31	120-137	124	31	116-133
Bank undercut (feet)	0.14	0.16	0.08-0.21	0.11	0.24	0.05-0.17	0.20	0.31	0.14-0.26
Bank depth (feet)	0.22	1.04	0.06-0.37	0.12	0.22	0.00-0.28	0.13	0.17	0.00-0.37
Fisheries rating	1.9	0.7	1.7-2.1	2.2	0.9	2.0-2.4	2.2	0.8	2.0-2.4
Streambottom									
Fines <0.03 in. (percent)	6.6	9.5	4.3-9.0	7.1	9.5	4.8-9.5	4.1	8.5	1.7-6.4
Fines >0.03 in (percent)	1.7	3.8	0.0-3.6	4.8	9.9	2.9-6.7	4.1	7.7	2.1-6.0
Gravel (percent)	48.9	25.3	43.1-54.7	49.5	22.1	43.7-55.3	49.5	20.2	43.7-55.3
Rubble (percent)	38.3*	25.9	33.0-43.5	27.1	15.8	21.8-32.4	37.0	18.5	31.7-42.2
Boulder (percent)	4.5*	7.1	2.0-7.0	11.5	13.1	9.0-14.0	5.3*	8.5	2.8-7.9
Substrate embeddedness	3.0	0.52	2.8-3.1	2.9	0.7	2.8-3.1	3.1	0.6	3.0-3.3
Instream vegetation cover (feet)	0.5	1.0	0.2-0.8	0.9	1.4	0.6-1.1	0.4	0.9	0.2-0.7

[1/] SD - standard deviation.

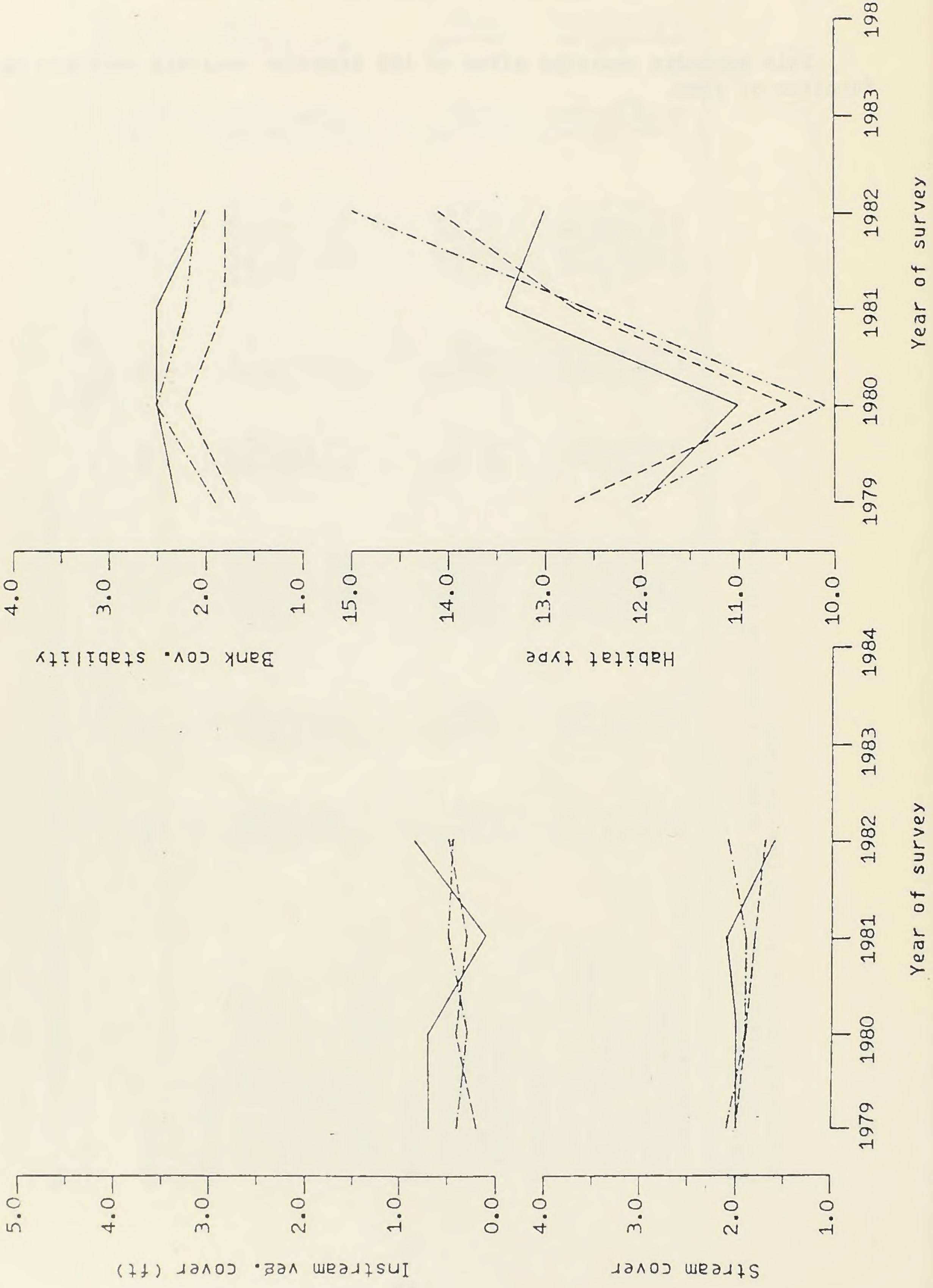
[2/] CI - 95% confidence interval; based on pooled variances for all sites.

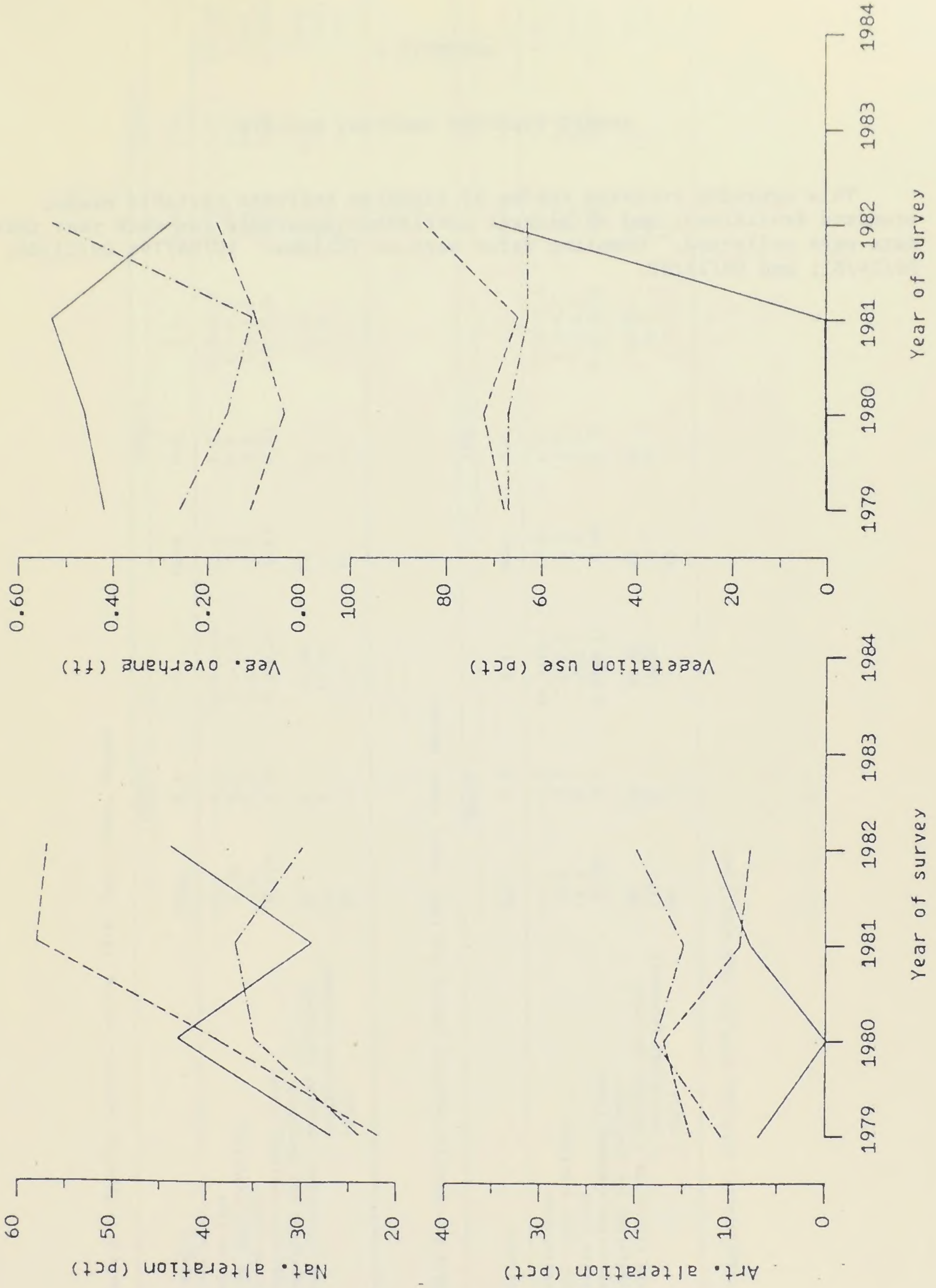
*Significantly different (P<0.05) from site 2 mean.

APPENDIX 3

Riparian Analysis Time Trend Plots

This appendix contains plots of the riparian analysis variable means as a function of time.


Instream veg. cover (ft)
0.0
1.0
2.0
3.0
4.0
5.0
Stream cover
1.0
2.0
3.0
4.0
Bank cov. stability
1.0
2.0
3.0
4.0
Habitat type
10.0
11.0
12.0
13.0
14.0
15.0
1979
1980
1981
1982
1983
1984
Year of survey
1979
1980
1981
1982
1983
1984
Year of survey


Nat. alteration (pct)
60
50
40
30
20
Art. alteration (pct)
40
30
20
10
0
1979
1980
1981
1982
1983
1984
Year of survey
Veg. overhang (ft)
0.60
0.40
0.20
0.00
Vegetation use (pct)
100
80
60
40
20
0
1979
1980
1981
1982
1983
1984
Year of survey

APPENDIX 4

Annual Riparian Analysis Results

This appendix contains tables of riparian analysis variable means, standard deviations, and 95 percent confidence intervals for each year that data were collected. Sampling dates were as follows: 10/08/79; 09/03/80; 08/24/81; and 09/27/82.

Table A-5--Riparian analysis results, 1979, Tabor Creek, Nevada

	Site 1			Site 2			Site 3		
Variable	Mean	S.D.	C.I.	Mean	S.D.	C.I.	Mean	S.D.	C.I.
Habitat type	13.7	4.2	12.6-14.9	13.1	4.9	11.9-14.2	13.1	4.7	11.9-14.3
Bank cover stability	1.7*	0.4	1.5-1.8	2.3	0.8	2.1-2.5	1.9*	0.7	1.7-2.1
Stream cover	2.0	0.3	1.8-2.2	2.0	0.8	1.8-2.2	2.1	0.9	1.9-2.3
Vegetation overhang (feet)	0.11*	0.16	0.0-0.22	0.42	0.60	0.31-0.54	0.26	0.48	0.14-0.37
Vegetation use (percent)									
Bank alteration - natural (percent)	22	14	19-26	27	11	24-31	24	14	20-27
- artificial (percent)	14	8	12-16	7	9	5-9	11	7	9-13
- total	36	--	--	34	--	--	35	--	--

Table A-6--Riparian analysis results for 1980, Tabor Creek, Nevada

	Site 1			Site 2			Site 3		
Variable	Mean	S.D.	C.I.	Mean	S.D.	C.I.	Mean	S.D.	C.I.
Habitat type	11.5	4.3	10.3-12.7	12.2	4.7	11.0-13.4	11.1	5.3	9.8-12.3
Bank cover stability	2.2	0.8	2.0-2.5	2.5	1.0	2.2-2.7	2.5	1.0	2.2-2.7
Stream cover	1.9	0.6	1.7-2.1	2.0	0.6	1.8-2.1	1.9	0.7	1.8-2.1
Vegetation overhang (feet)	0.04*	0.7	0.00-0.17	0.46	0.74	0.32-0.59	0.16*	0.49	0.03-0.29
Vegetation use (percent)									
Bank alteration - natural (percent)	39	20	33-45	43	29	37-49	35	16	29-41
- artificial (percent)	17*	12	14-20	0	0	0-3	18*	17	15-21
- total	56	--	--	43	--	--	53		

*significantly different ($P<0.05$) than site 2 mean.

Table A-7--Riparian analysis results for 1979, Tabor Creek, Nevada

	Site 1			Site 2			Site 3		
Variable	Mean	S.D.	C.I.	Mean	S.D.	C.I.	Mean	S.D.	C.I.
Habitat type	13.7	6.2	12.4-15.0	14.4	4.3	13.1-15.7	13.6	4.9	12.2-14.9
Bank cover stability	1.8*	0.8	1.6-2.0	2.5	1.0	2.3-2.8	2.2	0.9	1.9-2.4
Stream cover	1.8	0.7	1.6-1.9	2.1	0.6	1.9-2.1	1.9	0.8	1.7-2.1
Vegetation overhang (feet)	0.10*	0.14	0.0-0.19	0.53	0.58	0.44-0.63	0.11*	0.02	0-21
Vegetation use (percent)	65*	20	61-70	0	0	0-4	63*	20	59-67
Bank alteration - natural (percent)	58*	14	55-62	29	12	26-33	37*	14	34-41
- artificial (percent)	9	6	8-11	8	7	6-10	15	8	13-17
- total	67	--	--	37	--	--	52	--	--

Table A-8--Summary of riparian analysis results, 1980, Gance Creek, Nevada

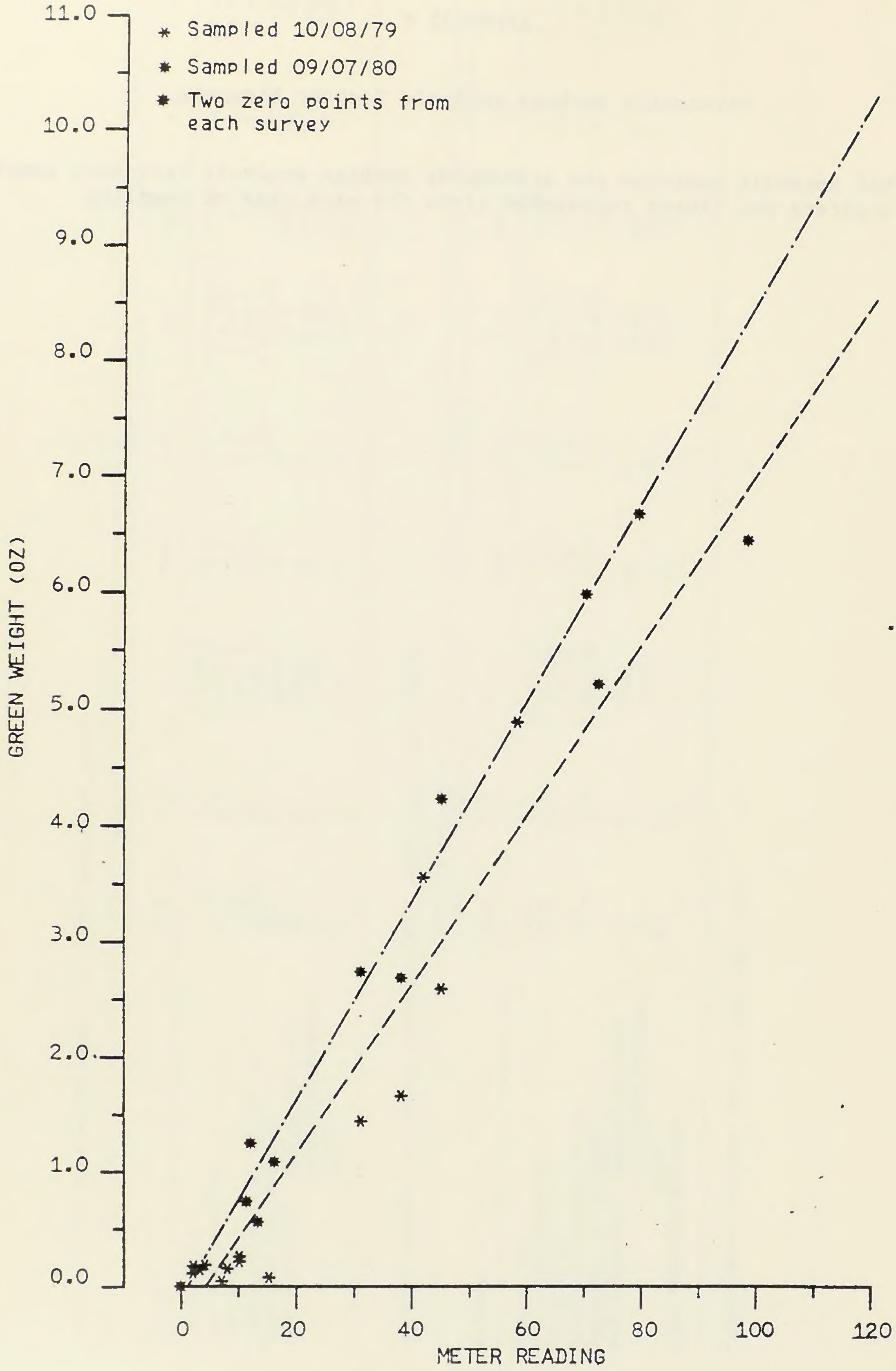
	Site 1			Site 2			Site 3		
Variable	Mean	S.D.	C.I.	Mean	S.D.	C.I.	Mean	S.D.	C.I.
Habitat type	15.1	3.8	14.2-16.0	14.0	3.5	13.1-15.0	16.0*	3.6	15.1-16.9
Bank cover stability	1.8	0.7	1.6-2.0	2.0	0.8	1.8-2.2	2.1	0.9	1.9-2.4
Stream cover	1.7	0.7	1.5-1.9	1.6	0.6	1.5-1.8	2.1*	0.9	1.9-2.3
Vegetation overhang (feet)	0.16	0.40	0.01-0.30	0.28	0.36	0.13-0.42	0.53	0.82	0.38-0.67
Vegetation use (percent)									
Bank alteration - natural (percent)	57*	13	52-61	44	17	40-49	30*	19	25-34
- artificial (percent)	8	5	6-10	12	6	10-14	20*	12	18-22
-total	65	--	--	56	--	--	50	--	--
Light intensity (percent)									

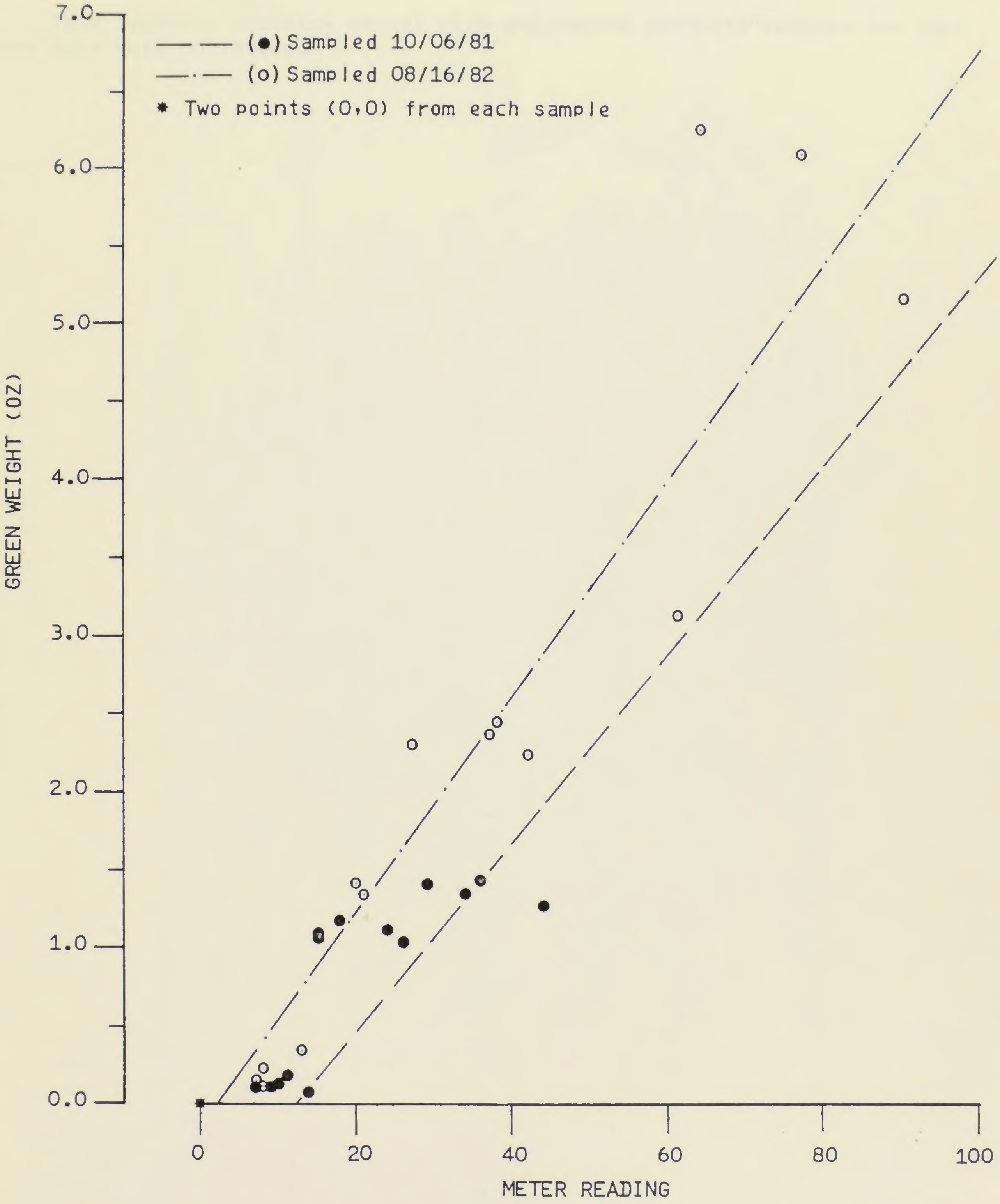
*significantly different (P<0.05) than site 2 mean.

APPENDIX 5

Streamside Herbage Analysis Scatter Diagrams

This appendix contains the streamside herbage analysis secondary sample point scatters and linear regression lines for each year of sampling.


* Sampled 10/08/79
✱ Sampled 09/07/80
✱ Two zero points from each survey
GREEN WEIGHT (OZ)
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120
METER READING


(●) Sampled 10/06/81
(o) Sampled 08/16/82
* Two points (0,0) from each sample
GREEN WEIGHT (OZ)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
METER READING
0
20
40
60
80
100

APPENDIX 6

Annual Fish Population Analysis Results

This appendix contains annual fish population analysis results for each year data were collected.

Table A-9.--Fish population analysis results for 1979, Tabor Creek, Nevada (sampled 08/13/79).

		Variable										
		Population estimate			Mean length		Mean weight				Standing crop[1]	
Study site	Total catch	No.	95% C.I.	X^2(3 df)	inches	95% C.I.	ounces	95% C.I.	Condition factor	Biomass[1] oz/ft^2(x10^{-2})	#/ft^2(x10^{-2})	#/mile
Rainbow trout												
Site 1	20	20	20-21	4.17	7.06	6.39-7.73	2.60	1.86-3.34	1.1	0.6	0.2	176
Site 2	39	39	39-41	1.57	6.95	6.52-7.38	2.50	1.96-3.03	1.1	1.6	0.6	343
Site 3	50	52	50-56	4.93	7.07	6.57-7.57	2.75	2.19-3.31	1.1	1.9	0.7	458
Sculpin												
Site 1	212	227	215-239	24.35	--	--	0.17	0.16-0.18	--	0.5	2.7	1,998
Site 2	305	352	324-380	26.13	--	--	0.16	0.14-0.18	--	0.9	5.7	3,098
Site 3	921	1166	1082-1250	60.95	--	--	0.08	0.06-0.09	--	1.2	15.8	10,261
Sucker												
Site 1	0	--	--	--	--	--	--	--	--	--	--	--
Site 2	14	14	14-17	4.57	--	--	1.08	0.80-1.37	--	0.2	0.2	123
Site 3	0	--	--	--	--	--	--	--	--	--	--	--
Dace												
Site 1	2	2	2-9	3.00	--	--	0.11	0.06-0.15	--	<0.1	<0.1	18
Site 2	0	--	--	--	--	--	--	--	--	--	--	--
Site 3	1	--	--	--	--	--	0.21	--	--	<0.1	<0.1	9

---

[1] Based on population estimate when available (program does not provide an estimate when fewer than 2 fish are collected).

Table A-10.--Fish population analysis results for 1980, Tabor Creek, Nevada (sampled 07/28/80).

		Variable										
		Population estimate			Mean length		Mean weight				Standing crop[1/]	
Study site	Total catch	No.	95% C.I.	X^2(3 df)	inches	95% C.I.	ounces	95% C.I.	Condition factor	Biomass[1/] oz/ft^2(x10^{-2})	#/ft^2(x10^{-2})	#/mile
Rainbow trout												
Site 1	27	28	27-32	5.30	3.34	2.24-4.45	0.99	0.24-1.74	1.7	0.3	0.3	246
Site 2	17	17	17-19	1.91	5.36	3.49-7.22	2.32	0.98-3.65	1.7	0.6	0.2	150
Site 3	68	68	68-70	6.01	9.48	9.04-9.93	5.32	4.81-5.82	1.1	4.7	0.9	598
Sculpin												
Site 1	124	134	124-151	1.28	--	--	0.22	0.15-0.28	--	0.3	1.5	1,179
Site 2	156	208	156-380	3.10	--	--	0.17	0.14-0.21	--	0.5	3.0	1,830
Site 3	374	528	386-670	--	--	0.16	0.16	0.15-0.17	--	1.1	6.9	4,646
Sucker												
Site 1	1	--	--	--	--	--	1.29	--	--	<0.1	<0.1	9
Site 2	9	9	9-10	3.80	--	--	1.08	0.73-1.42	--	0.1	0.1	79
Site 3	0	--	--	--	--	--	--	--	--	--	--	--
Dace												
Site 1	0	--	--	--	--	--	--	--	--	--	--	--
Site 2	1	--	--	--	--	--	2.00	--	--	<0.1	<0.1	9
Site 3	0	--	--	--	--	--	--	--	--	--	--	--

[1/] Based on population estimate when available (program does not provide an estimate when fewer than 2 fish are collected).

Table A-11.--Fish population analysis results for 1981, Tabor Creek, Nevada (sampled 08/20/81).

		Variable										
		Population estimate			Mean length		Mean weight				Standing crop[1]	
Study site	Total catch	No.	95% C.I.	X^2(3 df)	inches	95% C.I.	ounces	95% C.I.	Condition factor	Biomass[1] oz/ft^2(x10^{-2})	#/ft^2(x10^{-2})	#/mile
Rainbow trout												
Site 1	412	488	449-527	2.35	3.06	2.94-3.18	0.30	0.23-0.37	1.1	1.8	6.0	4,294
Site 2	308	325	313-337	5.40	3.22	3.07-3.36	0.33	0.26-0.40	1.2	1.7	5.0	2,860
Site 3	439	498	468-528	0.03	3.44	3.30-3.59	0.45	0.36-0.53	1.5	3.0	6.7	4,382
Eastern Brook Trout												
Site 1	0	--	--	--	--	--	--	--	--	--	--	--
Site 2	1	--	--	--	3.30	--	0.2	--	0.8	<0.1	<0.1	9
Site 3	0	--	--	--	--	--	--	--	--	--	--	--
Sculpin												
Site 1	622	966	791-1141	1.01	--	--	0.10	0.09-0.11	--	1.2	11.8	8,501
Site 2	551	624	589-659	28.21	--	--	0.10	0.06-0.15	--	1.0	9.6	5,491
Site 3	444	565	490-640	26.16	--	--	0.13	0.13-0.14	--	1.0	7.6	4,972
Sucker												
Site 1	32	38	32-52	1.24	--	--	1.08	0.81-1.26	--	0.5	0.5	334
Site 2	46	46	46-47	0.87	--	--	1.18	1.02-1.34	--	0.7	0.8	405
Site 3	0	--	--	--	--	--	--	--	--	--	--	--
Dace												
Site 1	4	4	4-16	13.71	--	--	0.17	0.00-0.42	--	<0.1	<0.1	35
Site 2	16	18	16-25	2.02	--	--	0.20	0.13-0.26	--	<0.1	0.3	158
Site 3	0	--	--	--	--	--	--	--	--	--	--	--

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[1] Based on population estimate when available (program does not provide an estimate when fewer than 2 fish are collected).

Table A-12.--Fish population analysis results for 1982, Tabor Creek, Nevada (sampled 08/09/82).

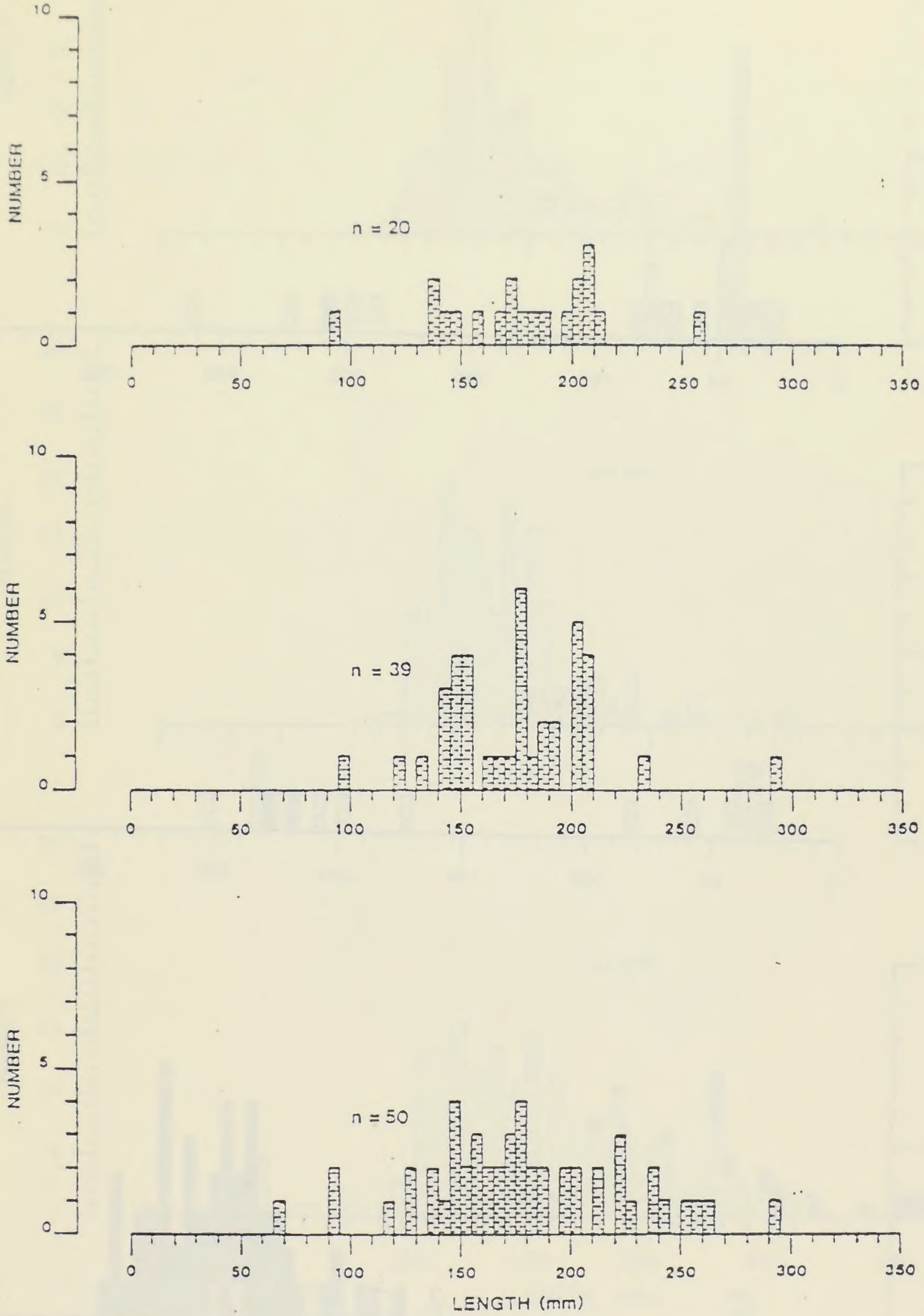
		Variable										
		Population estimate			Mean length		Mean weight				Standing crop[1/]	
Study site	Total catch	No.	95% C.I.	X^2(3 df)	inches	95% C.I.	ounces	95% C.I.	Condition factor	Biomass[1/] oz/ft^2(x10^{-2})	#/ft^2(x10^{-2})	#/mile
Rainbow trout												
Site 1	158	167	158-176	1.95	5.53	5.34-5.73	1.18	1.05-1.30	1.1	2.2	1.9	1,470
Site 2	192	194	192-198	6.11	5.57	5.40-5.74	1.29	1.15-1.42	1.1	1.7	2.6	1,707
Site 3	378	294	282-306	2.24	6.35	6.10-6.61	2.11	1.85-2.36	1.1	7.9	3.9	2,587
Sculpin												
Site 1	689	871	799-943	23.63	--	--	--	--	--	--	9.9	7,665
Site 2	679	785	742-828	33.82	--	--	--	--	--	--	10.4	6,908
Site 3	815	1,049	963-1135	74.50	--	--	--	--	--	--	13.3	9,231
Sucker												
Site 1	30	35	30-47	2.49	--	--	--	--	--	--	0.4	308
Site 2	49	50	49-53	--	--	--	--	--	--	--	0.7	440
Site 3	4	4	4-23	8.27	--	--	--	--	--	--	<0.1	35
Dace												
Site 1	17	20	14-44	3.52	--	--	--	--	--	--	0.2	176
Site 2	14	14	14-16	8.57	--	--	--	--	--	--	0.2	123
Site 3	0	--	--	--	--	--	--	--	--	--	--	--

[1/] Based on population estimate when available (program does not provide an estimate when fewer than 2 fish are collected).

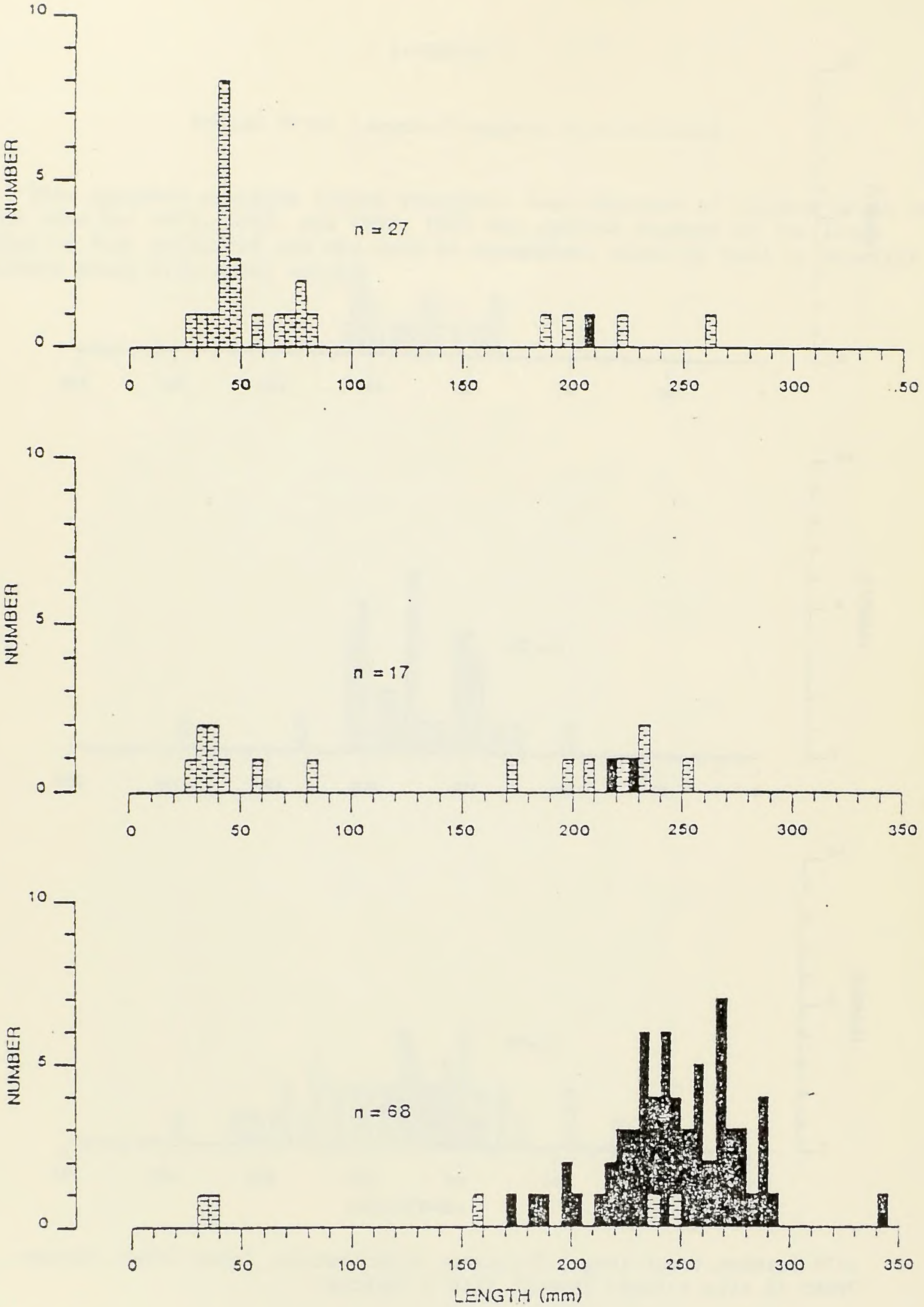
APPENDIX 7

Annual Trout Length-Frequency Distributions

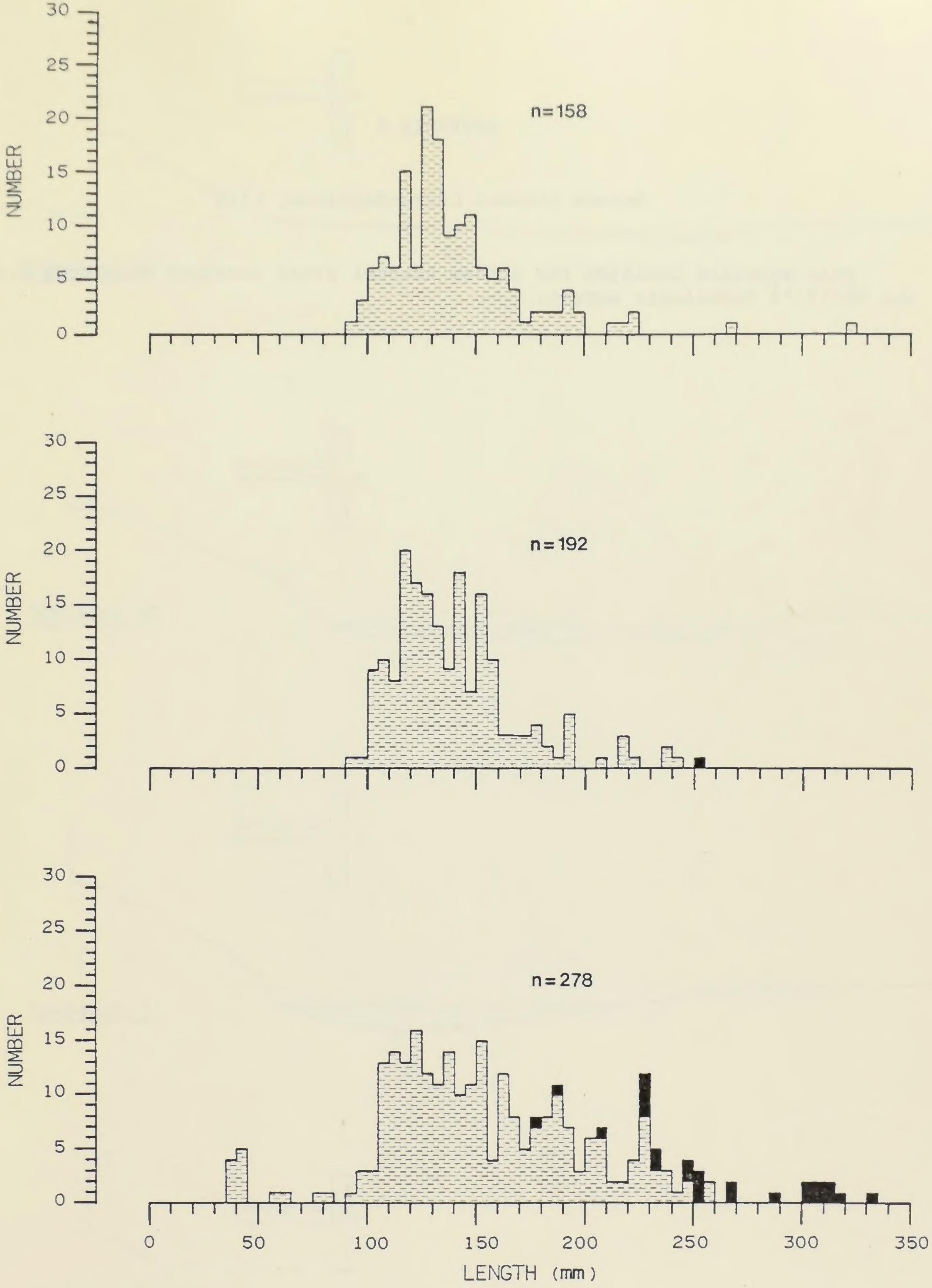
This appendix contains length frequency distributions of rainbow trout by study site for 1979, 1980, and 1982; 1981 was omitted because of the large number of fish collected and the need to draw these plots by hand to separate hatchery stock from total stock.



1979 rainbow trout length-frequency distribution, Tabor Creek, Nevada. Order is site 1 (top) through site 3 (bottom).



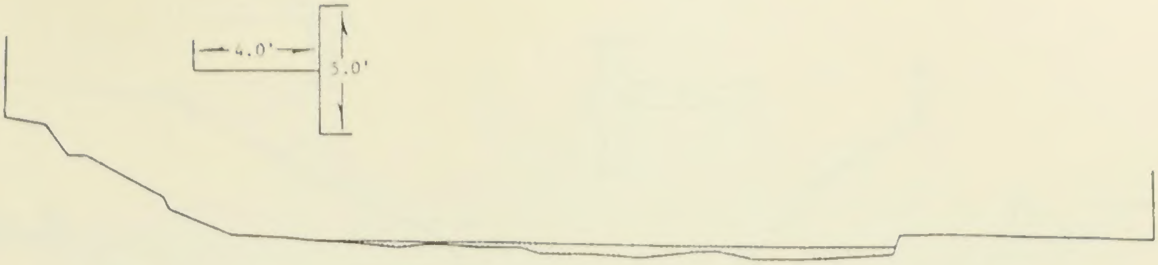
1980 rainbow trout length-frequency distributions, Tabor Creek, Nevada. Order is site 1 (top) through site 3 (bottom); shaded areas indicate hatchery stock.


n=158
n=192
n=278
NUMBER
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
LENGTH (mm)

APPENDIX 8

Stream Channel Cross-Sections, 1979

This appendix contains the stream channel cross sections resulting from the 08/13/79 hydrologic survey.



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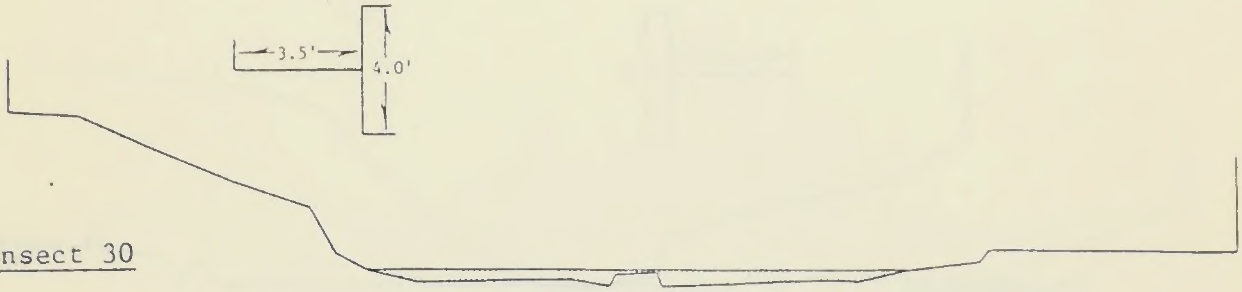

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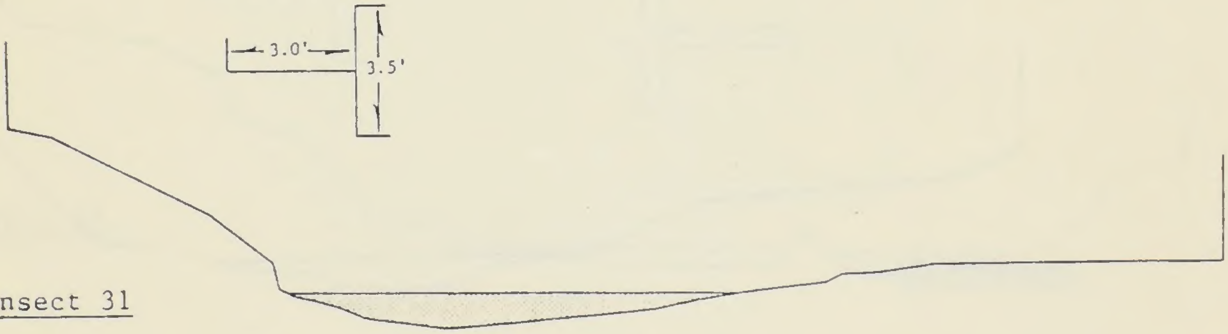

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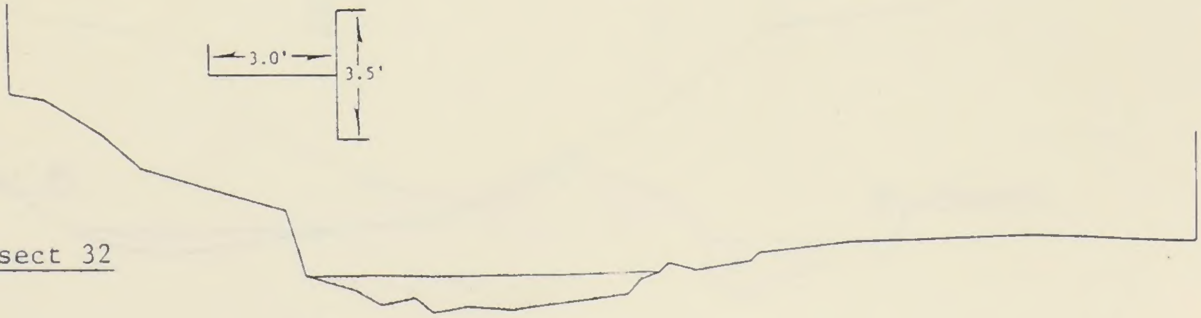

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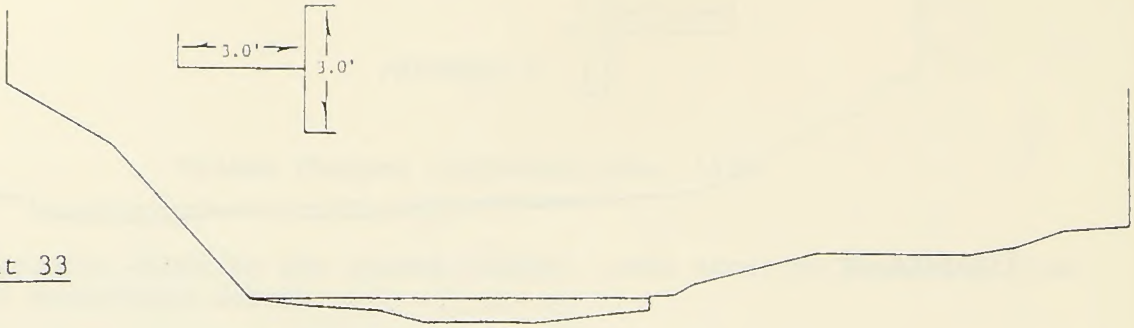

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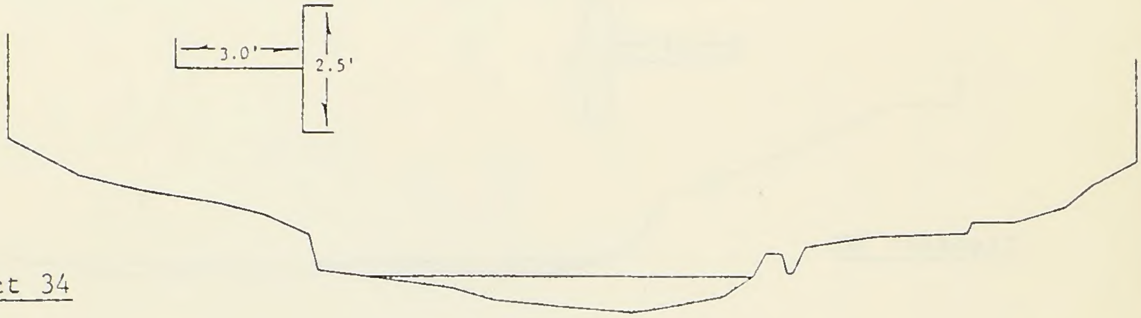

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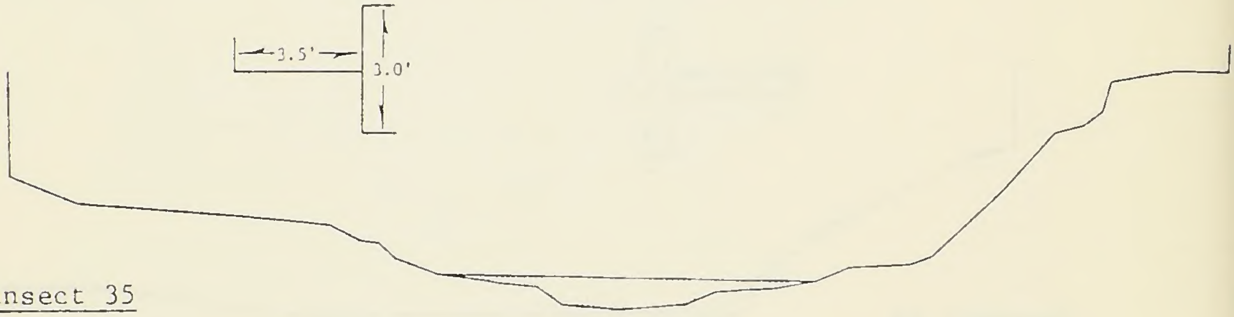

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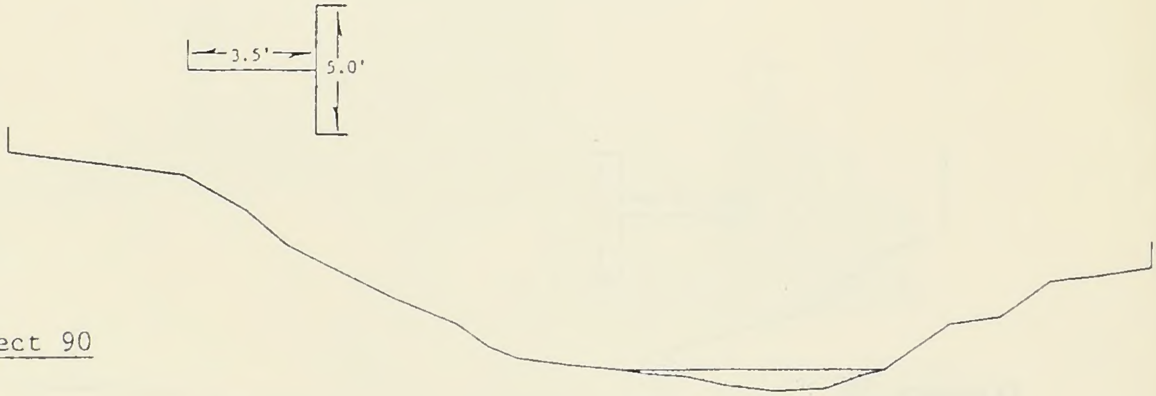

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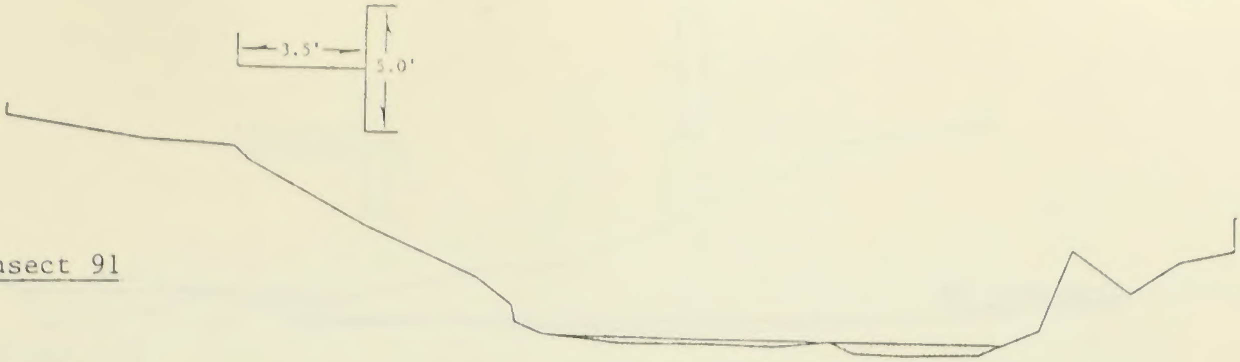
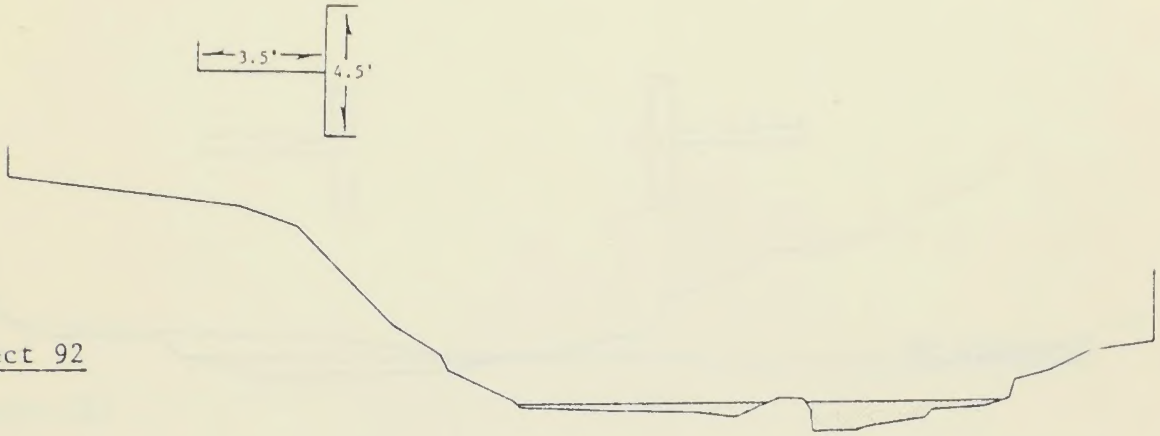


Transect 91



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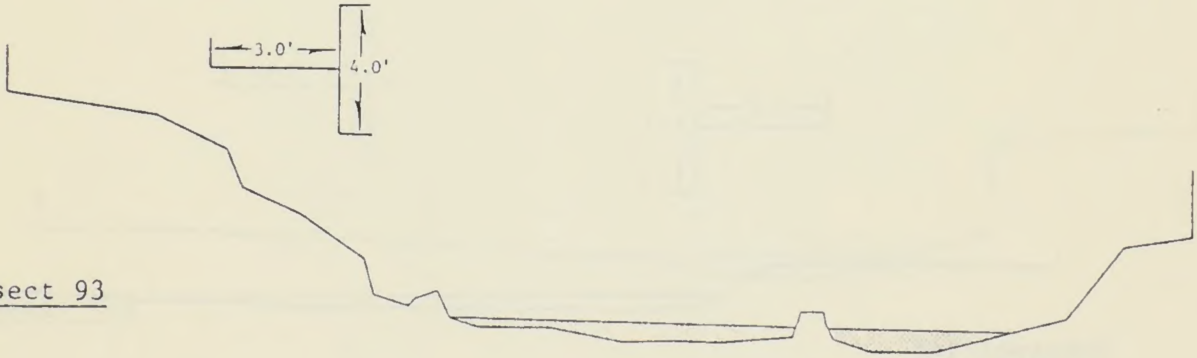

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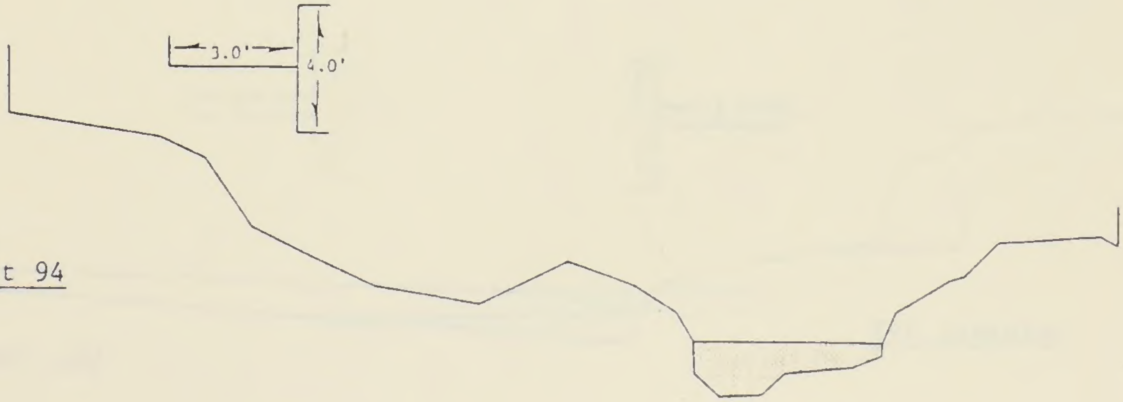

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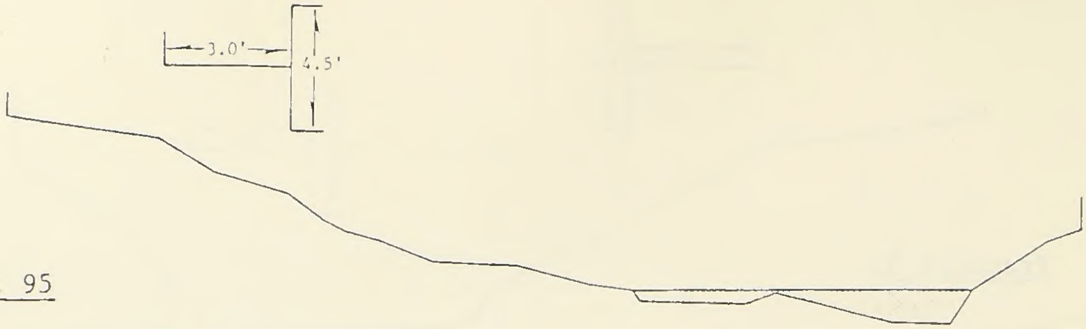

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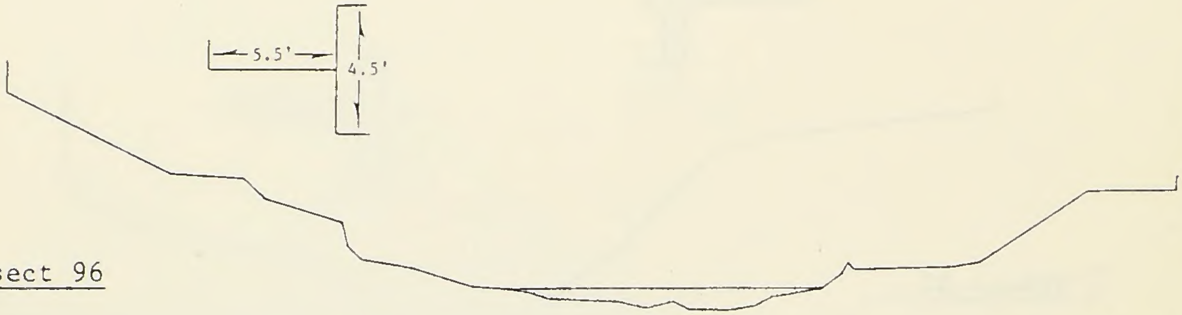

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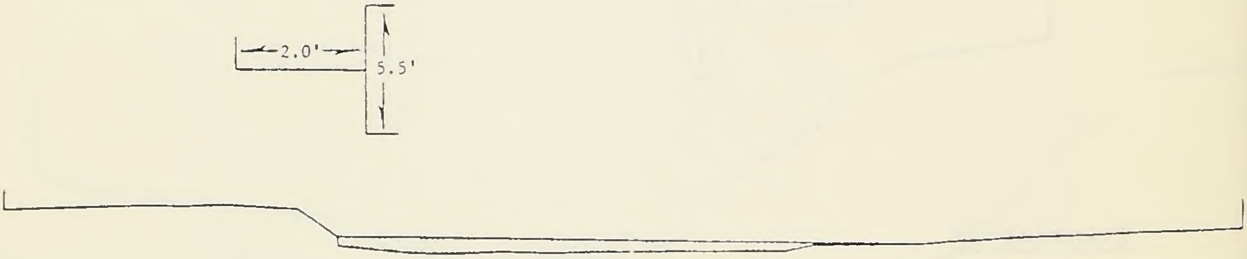

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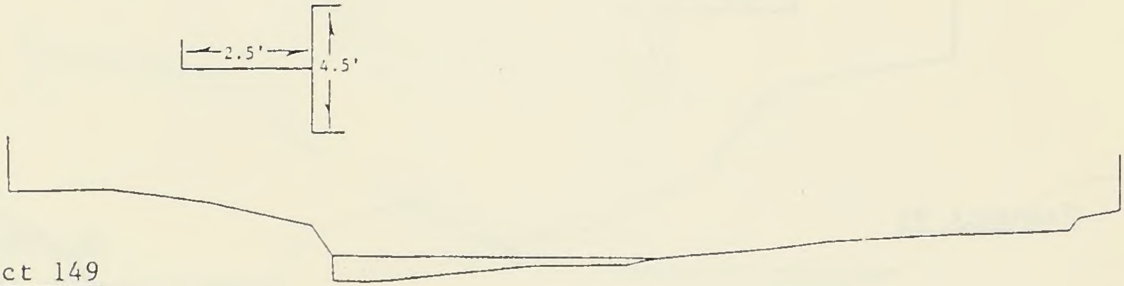

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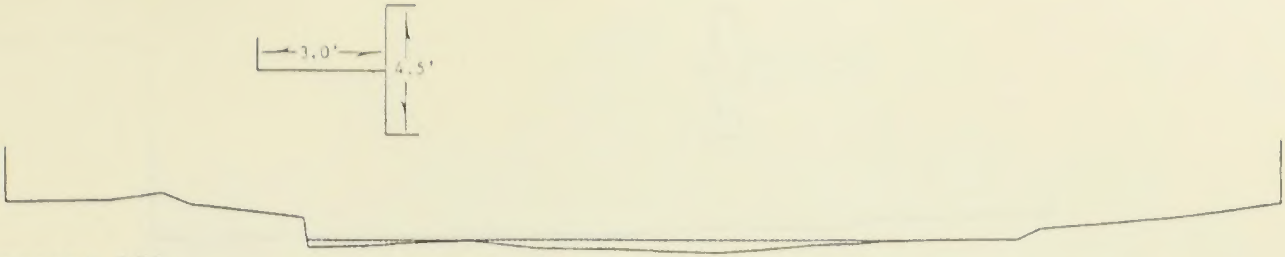

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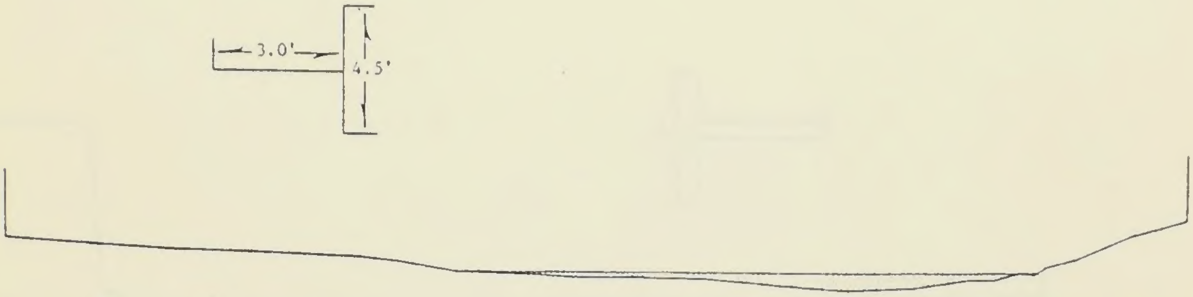

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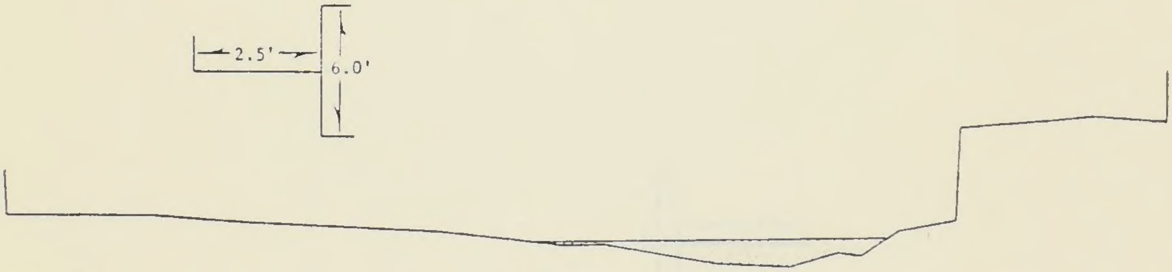

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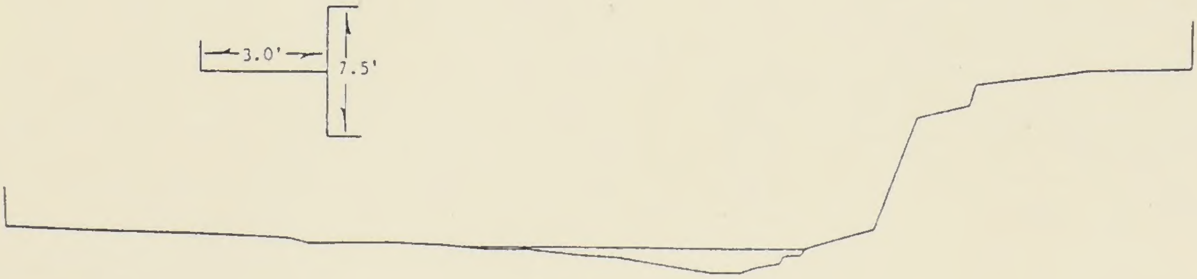

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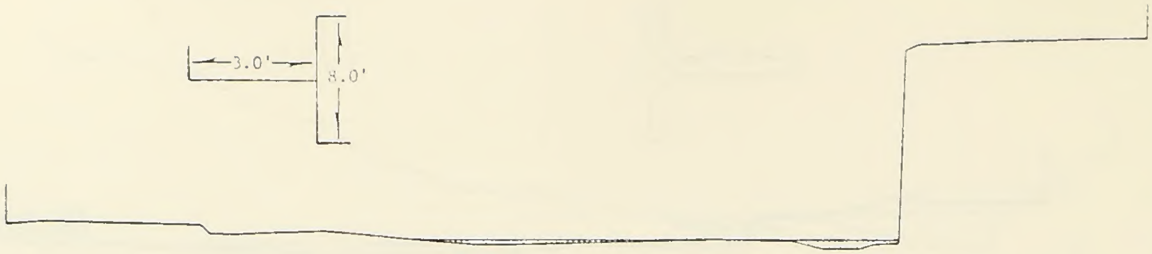

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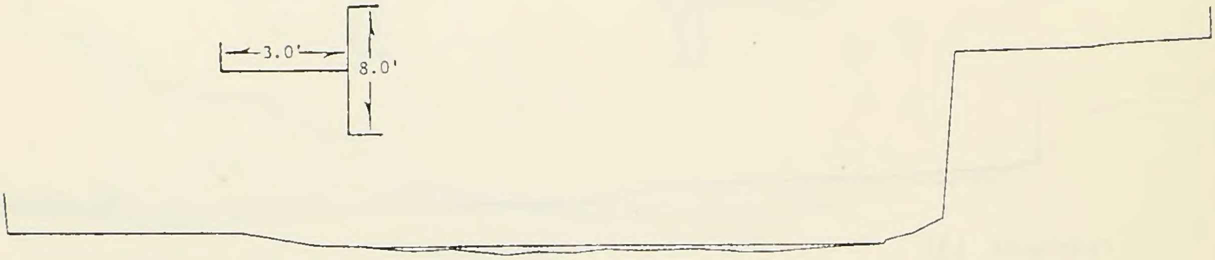

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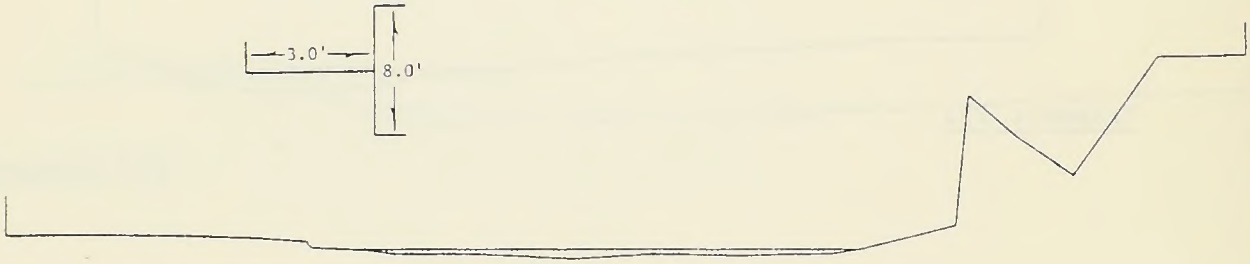

Transect 156